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PREFACE.

An enlarged and improved edition of the treatise on Field Fortification—which has for many years been in use as the text-book for this branch of study in the Military Academy—being called for, to meet the present wants of the service, the author has thought it advisable to comprise, in the same volume with it, the subjects of Military Mining and Siege Operations, both of which have found such extensive applications in several of the late remarkable sieges, in this country and in Europe, where the chief defences consisted of a simple line of field works.

In the preparation of the present edition, the author has endeavored to present the subjects comprised in it in the most simple and concise manner, so as to bring them within the easy comprehension of any person of ordinary attainments; in the hope that the work may prove serviceable to officers who have not had opportunities of pursuing a regular course of military studies, and also be found a useful auxiliary in the popular courses of military instruction which have of late been introduced into many of our civil institutions of education.

The author would here acknowledge his obligations to General Barnard, General Gillmore, and Colonel Merrill of the United States' Volunteers, and officers of the United States Corps of Engineers, for much valuable information embodied in the work.

United States Military Academy,
West Point, N. Y., *March* 21, 1865.

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INTRODUCTORY, CHAPTER I.

THE MANNER OF REPRESENTING, BY DRAWINGS, FIELD FORTIFICATIONS AND THE GROUND OCCUPIED BY THEM.

I. As field fortifications usually present volumes of very simple forms, in which the bounding surfaces are planes, and the bounding lines right lines, the manner of representing these by drawings is also correspondingly simple. In most cases demanding only one or more profiles and a plan of the fortifications.

II. By the term *profile* is understood the outline of a vertical section made through any part of the fortification in a direction perpendicular to its principal bounding lines; this outline being drawn according to certain prescribed rules.

III. By the term *section* is understood the outline of a cut made in any other than a perpendicular direction to the principal lines. When the cut is vertical it is termed a *vertical* section, when horizontal, a *horizontal* section, and sometimes a *plan*.

IV. By the term *plan* is understood a drawing which represents the relative position, estimated horizontally, of the outlines, or bounding lines of the surfaces of the fortifications with respect to each other.

The plan gives the horizontal distances alone. The profile both horizontal and vertical distances between the points represented on them.

V. By the term *elevation* is understood a drawing which represents the outlines of the fortifications as they appear to the eye of a spectator looking at them from a point in front of them.

Elevations give the relative positions estimated vertically of the lines represented. They are used only for drawings of a somewhat complex description, and in which it is desirable to convey, by the drawing, some idea of the appearance of the body represented.

VI. When the surface of the ground, or the *site*, on which the fortification is erected is horizontal, or so nearly so that the variations in height of the different portions of its surface may be left out of consideration, it is represented simply by the surface upon which the plan is drawn

VII. But when the surface is so irregular that it cannot be regarded as horizontal, then it has to be represented by lines, either in the manner adopted usually in maps, or else by the method used in topographical maps of the most accurate character.

These symbols are written as represented upon the curves, one alone being regarded as sufficient.

IX. The symbols are termed *references*. The curves with the symbols written on them, *horizontal curves*. The fixed plane, from which all the distances are estimated, is termed the *plane of reference*, or of *comparison*, or the *datum plane*.

X. Some inconvenience may at times arise by taking the plane of comparison at the lowest water level, should curves be required below it; as in that case, in order to distinguish these last from the first, the symbols would have to be written with the minus sign before them, as —(1.0), —(3.0). This, however, can always be obviated by assuming the fixed plan at any arbitrary level below every curve and point to be represented. When below the water level, these curves are sometioms represented by broken lines.

XI. In constructing the section, the horizontal lines in which the horizontal planes of the curves are cut are usually put down, with the references on the curve of section as shown in Fig. F.

XII. The lines and the points of all the fortification can be represented in their relative positions in the same manner as the curves and sections of the ground. To designate any point on the plan, the point is embraced within the symbol thus (·8.45), which expresses that the point is eight feet and forty-five hundredths of a foot above the plane of reference. A right line, which is not horizontal, may be represented by the reference of each extremity as shown on the lines mn, op, qr, and st, Fig. D; and when horizontal a single reference is written upon the line as in horizontal curves.

XIII. To draw a profile, a line representing a section of the natural surface is first drawn. When the surface is horizontal this will be a right line. We next assume (Figs. A, B) any starting point, as A, from which the horizontal distances are successively set off towards the right. From the points thus set off, as b, c, etc., perpendiculars are drawn to the line of the ground, and upon these, in succession, the vertical heights above the line of the ground are set off; by joining the points thus set off by right lines, the broken line A B C D, etc., obtained, is the outline of the profile of the embanked portion of the fortification. In like manner setting off the horizontal distances F G, G h, etc, and the vertical distances h H, i I, to which the excavation extends below the surface, and joining F H, etc., the broken line F H I K is the outline of the excavation from which the embankment is formed.

The drawing is completed as shown; the embanked portion by short parallel lines put in within the outline; the part excavated with like lines with others drawn across them as shown.

The profile being assumed as uniform throughout, the lines in plan which correspond to the points A, B, C, etc, of the profile, will be horizontal and parallel, and will be drawn parallel to each other on the plan, as shown.

XIV. The profile is usually drawn separate from the plan and to a larger scale; but to show the connexion of the two it is often drawn on the plan where it is supposed to be taken, or a little beyond it on the prolongation of the lines of the plan as shown on Figs. A, B.

XV. The horizontal and vertical distances of points should be very carefully written on the profile in numbers, the foot being taken as the standard measure, and the distances being expressed in feet and duodecimal or decimal parts of a foot. These numbers should be written upon or along the line, and an arrow head should be placed at each end of the distance designated by the number. The standard unit for the distances on the plan is usually the yard, for the convenience of having fewer numbers to write.

Fig. A.

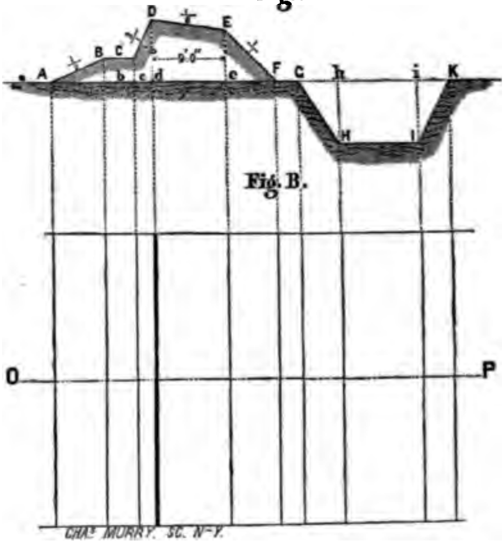


Fig. A. Section of Parapet and Ditch of a Field Work on a horizontal site. Fig. B. Plan or Horizontal Projection of the Parapet and Ditch.

The uniform slopes of embanked parts are represented by a fractional number written along the slope, as $\frac{1}{1}$, $\frac{1}{2}$, $\frac{1}{6}$, etc., which signify that the slope is *one*, *two*, or *six* base to *one* perpendicular, as the case may be.

Where the ground is horizontal and the profile uniform, there will be no necessity to use references on the plan, as the vertical distances are given on the profile.

XVI. The drawing should be made to a convenient scale. As has been stated, the profiles, sections, and elevations occupying less space than the plan, may be drawn to a larger scale than it. The scale of the plan will be regulated by the extent covered by the fortification and the size of the sheet on which the drawing is to be made.

XVII. When the ground is not horizontal, the first thing to be done is to construct with care the outline of the profile of the ground A X (Fig. C), to the extent covered by the profile of the fortification. This is done by assuming a starting point A of which the reference is known, and through it drawing a horizontal line A x′, as a *datum* line, along which the horizontal distances are to be set off, and the vertical distances on lines perpendicular to it. Taking a given horizontal distance *A* x′, the vertical distance x′ x of the point on the ground corresponding to it, will be readily found from the reference of the horizontal curve drawn through it; and in like

Fig. C.

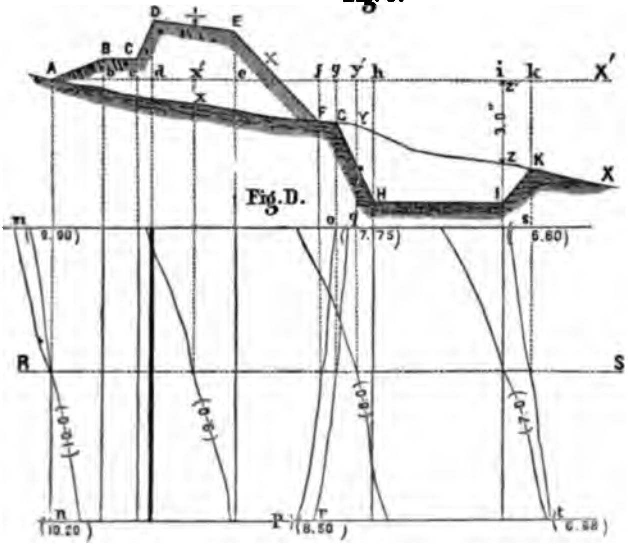


Fig. C. Section of Parapet and Ditch on an Inclined Site or Sloping Ground. Fig. D. Plan of the Parapet and Ditch and of the Horizontal Curves of the Site.

manner the distances y′ y, z′ z of the points y and z below A x′. The line A x y z X drawn through the points thus set off, is the profile of the ground. In like manner the horizontal distances from A of the points of the embankment and excavation will be set off from A, and the vertical distances of the points of the profile above and below A X′, and these points joined by lines to complete the outline; the profile being numbered and finished as already prescribed.

In these two figures the lines on the plan corresponding to the points B, C, D, and E, are horizontal; but the lines mn, op, qr, and st, corresponding to the points A and K, on Fig. C, where the embankment joins the natural surface, are curved and follow the fall of the surface The base of the embanked portion and the upper part of the excavation will also be irregular in their widths.

XVIII. The drawing of the plan will be somewhat more complex than for a horizontal site If the upper lines of the embankment are all parallel, they will be so drawn in the plan. To obtain those which correspond to A and F, in which the embankment meets the natural surface, several profiles [illegible] a [illegible] [illegible] [illegible]. The [illegible] of the [illegible] which [illegible] to the [illegible] [illegible] to the [illegible] [illegible] [illegible] lines which will be [illegible] [illegible] to the [illegible] [illegible] sufficiently [illegible] for the purpose. In the [illegible] the [illegible] of the [illegible] corresponding to [illegible] and [illegible] may be [illegible] [illegible].

It will be well [illegible] [illegible] the [illegible] [illegible] [illegible] to [illegible] [illegible] to all the points which are [illegible] [illegible] [illegible] to show with accuracy to the eye their position with respect to the place of reference and to each other.

INTRODUCTORY, CHAPTER II.

ON THE EFFECTS OF MUSKETRY AND ARTILLERY, AND THE MEANS OF DIRECTING THEIR FIRE TO OBTAIN THE BEST RESULTS.

As the object of all defensive arrangements, whether artificial objects be raised, or the natural features only of a position be seized upon for the purpose, is to place troops under cover from the enemy's fire, and to enable them to deliver their own with effect, some knowledge of the chances of hitting a mark of given dimensions at various distances, as well as the influences which the undulations and character of the ground, and the physical and mental state of the party firing, may have upon their aim, are essential elements in estimating the probable effects to be produced. The object of this introductory chapter is to present, from the most recent and authentic sources, some of the facts *arrived at by experiment*, which bear on the question.

I. *Remarks on Target Practice of Smooth-Bore Small Arms.* There is no fact more striking than the great disproportion between the number of combatants put *hors du combat* and the amount of ammunition expended, even in the most bloody engagements. Hundreds of instances might be cited in support of this. Military writers estimate that not more than one ball out of ten thousand attains its mark; and it is estimated, for example, that in the expedition of the French to Algiers, in 1830, which lasted but fifteen days, upwards of three millions of cartridges were consumed. The causes of this disproportionate application of means to an end, may be found partly in a careless use of his ammunition by the soldier; partly in the want of good instruction and frequent practice, particularly in those men who have not been familiar with the use of fire-arms from their youth; partly in the haste with which a fire against an enemy is delivered, which destroys calmness and good order, and impairs the aim; but chiefly by the over estimation of distance caused by fear, smoke, and the movable character of the mark.

Much depends upon the attention to his duties paid by the officer to prevent this. The men should be frequently practised at target firing, and be taught to note the influence which the firmness with which the piece is pressed against the shoulder, its depression or elevation, according to the distance of the target and the character of the ground, both as to the hardness of its surface and its undulations, have upon the accuracy of the aim. This practice should not be confined to the open field, but be also extended to the various positions in which soldiers may be placed behind breastworks and other shelters, such as palisades, stoccades, loopholed walls, abattis arranged for defence, etc., in order that the soldier may feel himself perfectly at home under all circumstances, and not be called upon to cast about for the best way of managing his piece in every new emergency. So far from urging the men to load and fire rapidly, every pains should be taken by the officer to impress upon them the necessity of not hurrying, of keeping perfectly cool, of loading steadily and aiming deliberately. Volley firing is admirable practice for this purpose; that by files is apt to give a slovenly and hurried action to the soldier. The fire of troops in line should be kept, as far as possible, under the control of the officer. His position and means of estimating distance enable him far better to judge of the proper moment than the men generally can. It is generally admitted that not more than four or five rounds can be fired in two minutes, allowing the men time to aim deliberately; three may be fired in one minute, but at the expense of a good aim.

As all infantry now are instructed as well in the duties of skirmishers as in the ordinary service of the line, they should be practised at firing both at a small mark, like the ordinary round target, and at a large square one, with black bands made across it, showing the ordinary height of the knees, centre of the body, the breast, shoulders, head and top of the cap.

As the point blank of the musket fired with the bayonet off is at about 120 or 130 yards, to attain a point at this distance, it must be directly aimed at; when it is at a distance short of this the aim must be below it; and when at one over this, the aim must be above it. With the bayonet fixed the musket has no point blank, and to hit a point the aim must always be above it.

The following rules for aiming are given by Piobert, a recent French author of high standing, in a work on artillery, as drawn from the practice of the French.

To hit the centre of the body, at all distances up to 110 yards, with bayonet fixed, aim at the breast.

To hit the same point, from 110 to 150 yards distance, aim at the shoulders.

To hit the same point, from 150 to 200 yards distance, aim at the head.

To hit the same point, from 200 to 220 yards distance, aim at the top of the cap.

To hit the same point, from 220 to greater distances, aim according to circumstances.

II. *Probable Effects of Small Arms.* Beyond 220 yards the effect of the fire is very uncertain. Beyond 450 yards the ball seldom gives a dangerous wound, although the musket, fired under an elevation of 4° or 5°, will carry from 600 to 700 yards, and under greater elevations over 1000 yards.

The nature of the surface of the ground, as has already been stated, has considerable influence upon the efficacy of the fire. In broken, or ploughed ground, fire is less effective than on an even firm surface, since in the former the balls that strike it are embedded, whereas in the latter they *ricochet*, and thus attain their mark; it being estimated that, under favorable circumstances, abcut one-seventh of the balls produce their effect in this way.

Table of effects of fire on a target five feet nine inches high, and ninety-five feet in length.

No. of balls out of 100 that hit the mark.	Distance to the Target in yards.					
	85	170	255	340	425	510 yds.
On even ground by direct and ricochet shots	75	50	27	20	14	7
On broken ground by direct shots	67	33	16	6	3	5
Penetration into pine, etc., in inches at same distances	3.3 in.	2.2	1.2	0.7	0.4	0.1
Penetration into oak same distances	4 in.	2.3	1.2	0.6	0.4	0.1

Decker, a German author of reputation, lays down the following as the probable number of balls out of 100 which will attain their aim when fired by well instructed troops, making full allowance for the over-estimation of distances in firing on an enemy:

Troops	firing in line	at 300	paces,	out of 100 balls	1	will touch.
"	"	200	"	"	20	"
"	"	100	"		40	"
"	as skirmishers	400	"	"	5	"
"	"	300	"	"	10	"
"	"	200	"	"	30	"
"	"	100	"	"	50	"
Rifle	practice	400	"	"	10	"
"	"	300	"	"	20	"
"	"	200	"	"	72	"

The firing of skirmishers is the more effective from the greater deliberation in aiming and in seizing upon the opportune moment. Volleys produce a tremendous staggering effect, by the simultaneous fall of numbers, when they are coolly thrown in at short ranges. To produce this effect they ought not to be delivered at greater distances than 200 paces.

Decker condemns file firing except for the purpose of occupying new troops when first brought before an enemy.

III. *Ranges and probable effects of Smooth-Bore Field Artillery.* In artillery practice, the greatest deliberation and coolness must be exercised to obtain good results. There are so many circumstances which affect the aim of artillery, that nothing but the most careful attention to the effects produced by the first few rounds will enable the officer to manage his guns with advantage.

The point blank range of six-pounder field guns is about 600 yards, and that of twelve-pounders about 700 yards. The chances of hitting a mark are less with pieces of small than of large calibre, owing to windage, the effect of wind, etc. The ranges of all calibres vary more when the pieces are fired under small angles of elevation than under large angles.

The following Tables of the number of balls out of 100 *which will attain a target six feet high and ninety-five feet in length, at various distances, is taken from Piobert:—*

Distances in yards.	550	70	1800
No. of 12-pounder shot (French) out of 100	57	88	19
" 6 " " " " "	49	82	12

Table of the number of balls out of forty-one in a canister which attain a butt six feet high, and fifty feet in length.

Distances in yards.	220	440	660
12-pounder canister (French)..........	9	9	4.5
8 " " "	8.3	7.4	4

The usual diameter of grape is about one-third that of the ball. To produce a good effect at a distance, grape ought not to be less than one inch in diameter. Smaller balls produce greatest effects at short distances. Grape of one-third the diameter of the ball has sufficient velocity at 880 yards with twelve-pounders, and 760 yards with eight-pounders, to disable men. When the distance is within 500 yards, the fire of grape is superior to that of ball against troops.

In howitzer practice the shells are fired with small charges, as they break easily when they strike an obstacle with a great velocity. The point blank of the howitzer varies with the charge. The greatest range of the twenty-four-pounder howitzer is about 2200 yards; that of the six-inch about 2600 yards.

The chances of hitting a mark with the howitzer diminish as the length of the bore, the calibre and weight of the shell decrease. The deviations with small charges are nearly double those with heavy charges.

The shell of the howitzer produces no effect when fired against masonry, as it invariably breaks. It imbeds itself in earth and wood, and bursting produces a considerable crater. The fragments of the shell are often thrown to distances over 600 yards, and they do great damage to objects near. The wounds from them are very dangerous. The shells loaded with incendiary composition are used to fire buildings.

The rate of firing for field guns is from 35″ to 40″ for six-pounders, and one minute for twelve-pounders. But when the enemy is close at hand, and deliberate aim not necessary, two rounds may be fired per minute.

IV. *Selection of positions for Field Batteries.* The position taken up on the field for a battery must be looked at in a double point of view. 1st.

as to its suitableness for annoying the enemy, and 2d, as to its being favorable for limiting the effects of the enemy's fire aimed at the battery.

As a general rule artillery should overlook all the ground over which an enemy might advance, the pieces of heaviest calibre being placed on the most commanding points. The batteries, however, should not be within musket range of woods, or of any ground where the enemy's sharpshooters might find cover to annoy them. The slope of the ground on which the gun rests must not be too oblique to the line of fire, otherwise the shot will not tell; the declivity of the ground should never exceed one perpendicular to fifteen base. When the ground between the battery and the enemy is horizontal and firm, it will be best to take a position near the enemy, as the ricochet shots on such ground do not rise much. If the ground is uneven a distant position may be more favorable to obtain a grazing fire. Positions should be so chosen that hollows, woods, villages, etc., on the front or flank of the line occupied by the troops, may be thoroughly swept, to prevent the enemy's columns from approaching under cover.

Advantage should be taken of any unevenness of ground to place the artillery under cover until called into action. But all broken ground occupied by batteries should be thoroughly examined, and the avenues leading to it, by which the enemy's cavalry might fall upon the batteries, should be obstructed. Stony ground is a bad position for a battery, owing to the effect of the enemy's shot in scattering stones. Very even ground is unfavorable, as well as uneven ground which opens in a funnel-shape outwards from the battery, as the enemy is enabled in either case to concentrate his fire from an extended front upon the battery. Rough ground breaks the effects of the enemy's ricochet shots, and when it presents bluffs or perpendicular faces towards the enemy it will stop the balls that strike those parts. Undulating ground hinders the enemy from observing the effects of his fire. If the ground in rear of the battery is hidden the enemy will generally aim too high; but if the battery is relieved against the sky it will assist his aim. It must be borne in mind that in taking advantage of undulations to cover a battery it will not do to fire from behind the covering ridge, as the aim and range will be rendered very uncertain. Batteries should never be placed directly in front of other troops, since they necessarily attract the enemy's fire to them, and would therefore cause great damage to the troops in rear.

V. *Management of the Fire of Batteries.* The management of the fire with regard to the projectile to be used is very important. It has been observed that the ball and howitz produce a greater moral effect upon troops than grape. When it is taken into consideration that a six-pounder shot will take off twenty-four ranks at a distance of 500 to 600 yards, the tremendous effect of a smashing fire of ball upon a column may be readily understood. A fire of ball or shells should, therefore, be opened upon troops at a distance, when they are in mass, in several lines, or when an enemy's line can be enfiladed. When an enemy's column is advancing a fire of ball should be opened on the head of the column; and if it be in retreat the aim ought to be directed on the centre. The fire of shells is good against cavalry, as it produces disorder from the explosion of the shell.

A fire of grape or canister should be opened on troops in line, or in open order, but not at distances greater than 600 or 800 yards. In an attack upon troops in line, a battery may advance to within 400 or 500 yards before opening its fire of grape; and even nearer if the ground is unfavorable to ricochet, and there is but little danger from an attack of the enemy's skirmishers on the flanks of the battery. When an enemy's battery advances nearer than point blank range, a fire of grape should be opened upon it, just at the moment when having commenced the movement to place the pieces in battery, the flanks of the horses will be offered to the fire.

As a general rule, the aim should be rather low, as ricochet shots produce considerable moral effect. For this purpose, when the ground is favorable to this fire, the aim should be at the mark, but rather under it for distances within 1200 yards; beyond this, and up to 1800 yards, when this fire becomes inefficacious, the piece may be fired with an elevation of one degree between its axis and the ground.

Our fire should be concentrated on several points in succession; but the pieces of the battery should be separated at wide intervals, when the position will admit of it, to offer fewer chances to the divergence of the enemy's shot. It is seldom of any use to fire a single piece at a small mark, as a group of a few individuals; if it be suspected that any important personage may be in such a group we should let them have the discharge of an entire battery at once.

The ammunition of the pieces should be economized, unless it be necessary to drown the fears of new troops in noise.

VI. *Position of Batteries in Attacking and Defending Intrenchments.* In the attack of intrenched positions, the batteries should be placed to obtain enfilading views on the enemy's lines, and a fire be opened with ball and shells from pieces of the heaviest calibre. When our column of attack has arrived near the works, the batteries should be so posted as to support it if repulsed.

In the defence of works, the pieces should be so placed as to cross their fire upon the ground over which the enemy must approach. The heaviest pieces should be placed on the most secure points, and in such positions that their fire may not incommode the troops defending the work. The light guns should be placed at the advanced points, as they can be most easily withdrawn. The howitzers should occupy points from which hollows, woods, etc., in advance of the works, can be reached by their shells.

VII. *Effects, etc., of Batteries for Harbor Defence.* As very erroneous and vague notions are at present afloat with respect to the effects of artillery against shipping and batteries, a statement of some of the more settled points may not be here misplaced.

Heavy ordnance, from twenty-four-pounder guns upwards, eight-inch sea-coast howitzers, commonly known as *Paixhan guns*, or *Columbiads*, and heavy mortars, should alone be used for harbor defences.

The projectiles of heavy guns, after ricocheting under angles of 4° or 5°

on water, lose but little of their velocity; the ball, for example, of a twenty-four-pounder, after a ricochet, preserves sufficient force to pierce the side of a wooden line-of-battle ship at 600 or 700 yards distance.

The destructive ranges of sea-coast howitzers, fired with heavy charges, are as high as between 3000 and 4000 yards. Those of heavy mortars are even greater, and their shells fired under great angles will break through two or three decks of a ship. Both of these projectiles produce the most destructive effects when they lodge and explode in timber or between decks.

Batteries, if properly placed, have the two-fold advantage of striking shipping either by a direct aim, or by ricochet; and this does not require, as is generally thought, that the battery should be at the water's edge. When shipping cannot approach nearer to the battery than between 200 and 300 yards, it may be from fifty to fifty-three feet above the water level and still attain a vessel by ricochet shot, by aiming rather low. To effect this the aim should be so taken that the ball, were it to plunge under the vessel, would pass about as far below the water level as the upper deck is above it. If vessels cannot get nearer than between 400 and 500 yards, then the battery will have the same advantages if placed from eighty to 100 feet above the water level. These advantages of ricochet double the chances of batteries, during a calm, at distances between 200 and 700 yards.

The effect of projectiles upon strong masonry is very gradual. It requires several hours of cool, systematic firing, at very short ranges, to open a useful breach in a well built wall of good stone. The effect of shells, fired against walls of brick even, is absolutely null, as they invariably break, and make but a slight impression upon the wall. A brick arch three feet thick, covered with about the same thickness of earth, will sustain, without injury, the shock of the largest shells falling from the greatest heights.

In the fire from shipping upon elevated batteries the advantages from ricochet shots are lost. Even when the battery is low, if the ground between it and the water be cut into perpendicular steps, the effects of ricochet will be considerably lessened, as every shot that strikes the face of a step will be stopped.

Batteries have this farther advantage over vessels, that the hull and rigging of the latter present a large vulnerable mark for every gun of the former. To compensate for this, ships can bring a large number of guns to bear on the same point.

When batteries are low, and the water will admit of shipping to approach within musket range, the gunners may be driven from their pieces by a fire from the ship tops. To provide against this, there should be a few light guns on secure points to fire into the tops with grape.

VIII. *Tables giving the Penetration of the Projectiles of Smooth Bore Cannon and Small Arms into various Media.*

In order to insure perfect security, the thickness of parapets ought to be one-half greater than the depth of penetration furnished by experiment.

As a general rule, the following dimensions may be taken for the parapets and other coverings for field works:

Brick wall of one brick		Musket proof.
Stone ditto, 6 inches		
White Pine fence, 12 inches		
Yellow ditto,	9 "	
Oak (seasoned),	4 "	
Earth, three to four feet		

Earthen parapet against field-pieces, from nine to twelve feet.

From experiments carefully made to ascertain the distance into which shot will penetrate the media in most common use for forming parapets, the following results have been obtained:

PENETRATION INTO ROUGH GOOD LIMESTONE MASONRY, WITH A CHARGE ONE-THIRD THE WEIGHT OF THE BALL.

18 pounder shot at about	80 yards	1 foot 9 inches.
18 " " "	110 "	1 " 8 "
18 " " "	330 "	1 " 4 "
18 " " "	660 "	1 " 0 "
9 " " "	80 "	1 " 4 "
9 " " "	100 "	1 " 3 "
9 " " "	330 "	1 " 0 "
9 " " "	660 "	0 " 7 "

By adding three-fourths of the above distances to themselves, the penetration into good brick masonry will be obtained.

The effect of shells fired against masonry is very trifling; they either break without exploding, or produce but a slight impression when they explode in contact with the masonry.

PENETRATION INTO OAK WOOD WITH SAME CHARGE.

18 pounder shot, at about	440 yards		3 feet 0 inches.
18 " " "	880 "		2 " 0 "
9 " " "	440 "		2 " 0 "
9 " " "	880 "		1 " 0 "
6 inch howitzer, "	440 "	charge 3·3 pounds	1 " 8 "
6 " " "	880 "	" "	1 " 0 "
24 pounder howitzer, "	440 "	" 2·2 "	1 " 8 "
24 " " "	880 "	" "	3 " 0 "

The penetration into white pine is about three-fourths greater than into oak.

PENETRATION INTO WELL RAMMED EARTH COMPOSED OF HALF SAND AND HALF CLAY.

18 pounder	110 yards		6 feet 6 inches.
18 "	440 "		5 " 5 "
18 "	880 "		4 " 6 "
9 "	110 "		4 " 4 "
9 "	440 "		3 " 4 "
9 "	880 "		2 " 8 "
6 inch howitzer	110 "	charge 3·3 pounds	4 " 0 "
6 " "	440 "	" "	3 " 0 "
6 " "	880 "	" "	2 " 0 "
24 pounder "	110 "	" 2·2 "	3 " 5 "
24 " "	440 "	" "	2 " 5 "
24 " "	880 "	" "	1 " 6 "

The penetrations into sand mixed with gravel were about 0.6 of the above; into earth mixed with sand and gravel, about 0.9; into compact soil of clay, sand, and mould, I.1; into common soil, loosely thrown up, about twice the above.

IX.

PENETRATION OF MUSKET BALLS.

Charge	134	grains, at	34	yards,	in oak........	3½	inches.
"	"	"	60	"	"	3	"
"	"	"	110	"	"	2½	"
"	"	"	220	"	"	1½	"
"	134	"	50	"	"	1½	"
"	154	"	30	"	rammed earth, of clay and sand	10	"
"	"	"	60	"	" " " "	9½	"
"	"	"	110	"	" " " "	8½	"
"	"	"	220	"	" " " "	6	"
"	"	"	24	"	bundle of fascines.......	24	"
"	"	"	40	"	packed wool of mattrasses............	40	"

X. *Extracts from Tables computed by Brevet-Major* MORDECAI, *showing the Velocities and Penetrations of Cannon Balls and Shells at various Distances from the Gun.*

The initial velocities used in computing these tables were, in most cases, obtained by direct experiment with the Balistic Pendulum at the Washington Arsenal.

Those of balls from the Columbiad were obtained by calculation on principles deduced from these experiments.

According to the French experiments at *Garré*, it appears that a ball will not stick in oak timber if it strikes the surface under a smaller angle than 15°, nor unless it penetrates to a depth nearly equal to its diameter.

The penetrations in other substances are obtained by multiplying those given by the following tables in oak, by the following co-efficients:

1.64 for compact earth, half sand and half clay.
1 06 for sand mixed with gravel.
2.21 for fresh earth.
1.29 for elm.
1.80 for beech and white pine.
2.00 for poplar.
0.19 for limestone rock.
0.41 for masonry of good quality.

VELOCITIES AND PENETRATIONS OF SHOT AND SHELLS FROM A 12-POUNDER SIEGE AND GARRISON GUN.

BALL.	SOLID SHOT.				SHELLS.			
Charge.	4 lbs.		3 lbs.		3 lbs.		2 lbs.	
Distance from Muzzle.	Velocity.	Penetration in Oak.	Velocity.	Penetration in Oak.	Velocity.	Penetration in Oak.	Velocity.	Penetration in Oak.
Yards.	Feet.	Inches.	Feet.	Inches.	Feet.	Inches.	Feet.	Inches.
0	1,906	46.75	1,674	40.75	1,900	33.5	1,610	28.
100	1,722	42.	1,522	36.5	1,651	28.75	1,415	24.
200	1,562	37.5	1,390	32.5	1,449	24.75	1,254	20.50
400	1,305	30.	1,172	26.	1,142	18.	1,002	15.
600	1,106	24.	1,000	21.	921	13.25	817	11.
800	948	19.25	862	16.75	755	9.75	676	8.
1,000	819	15.75	749	13.25	627	7.00	565	6.
1,200	714	12.25	686	10.75	526	5.25	476	4.25
1,400	626	10.	576	9.00	445	3.75	404	3.25
1,600	551	8.	509	7.00				
1,800	487	6.25	452	5.50				

VELOCITIES AND PENETRATIONS OF SHOT AND SHELLS FROM A 24-POUNDER SIEGE AND GARRISON GUN AND FIELD HOWITZER.

GUN.	24-POUNDER SIEGE AND GARRISON GUN.						24-POUNDER FIELD HOWITZER.		
Ball.	Shot.				Shell.		Shell.		Spherical Case.
Charge.	8 lbs.		6 lbs.		4 lbs.		2½ lbs.		2½ lbs.
Distance from Muzzle.	Velocity.	Penetration in Oak.	Velocity.	Penetration in Oak.	Velocity.	Penetration in Oak.	Velocity.	Penetration in Oak.	Velocity.
Yards.	Feet.	Inches.	Feet.	Inches.	Feet.	Inches.	Feet.	Inches.	Feet.
0	1,870	57.5	1,680	51.25	1,670	37.25	1,170	24.	1,000
100	1,730	53.	1,561	47.	1,518	33.75	1,076	21.25	948
600	1,224	34.75	1,122	30.75	979	18.50	785	12.	717
1,200	859	20.75	797	18.5	638	9.25	498	6.	582
2,400	478	7.5	444	6.75					

VELOCITIES AND PENETRATIONS OF SHOT AND SHELLS FROM A 32-POUNDER SEA-COAST GUN AND FIELD HOWITZER.

Gun.	32-POUNDER SEA-COAST GUN.						32-POUNDER FIELD HOWITZER.		
Projectile.	Shot.				Shell.		Shell.		Spherical Case.
Charge.	10½ lbs.		8 lbs.		5½ lbs.		3½ lbs.		3½ lbs.
Distance from Muzzle.	Velocity.	Penetration in Oak.	Velocity.	Penetration in Oak.	Velocity.	Penetration in Oak.	Velocity.	Penetration in Oak.	Velocity.
Yards.	Feet.	Inches.	Feet.	Inches.	Feet.	Inches.	Feet.	Inches.	Feet.
0	1,750	59.	1,650	55.25	1,650	40.	1,150	26.5	1,000
100	1,687	54.75	1,546	51.25	1,510	36.	1,067	23.00	949
600	1,208	37.50	1,150	35.	1,017	21.50	756	18.50	742
1,200	880	23.50	843	22.25	681	11.50	525	7.25	566
2,000	607	13.00	585	12.	427	5.00			
2,400	512	9.50	494	9.					

VELOCITIES AND PENETRATIONS OF SHOT AND SHELLS FROM 8″, 10″, AND 12″ COLUMBIADS.

CALIBRES.	EIGHT INCH.				TEN INCH.				TWELVE INCH.	
Projectile.	Shot, 65 lbs.		Shell, 50 lbs.		Shot, 128 lbs.		Shell, 100 lbs.		Shell, 172 lbs.	
Ch'ge.										
Distance from Muzzle.	Velocity.	Penetration in Oak.	Velocity.	Penetration in Oak.	Velocity.	Penetration in Oak.	Velocity.	Penetration in Oak.	Velocity.	Penetration in Oak.
Yards	Feet.	Inches.	Feet.	Inches.	Feet.	Inches.	Feet.	Inches.	Feet.	Inches.
0	1,375	56.	1,570	50.75	1,315	66.5	1,475	60.	1,200	54.75
100	1,314	53.	1,474	47.	1,270	63.5	1,409	56.75	1,159	52.25
1,200	853	23.5	818	20.5	900	38.75	896	30.25	818	31.25
2,400	563	14.25	485	8.50	643	22.5	590	15.25	584	17.77
4,000	345	5.75			483	11.00	368	6.25	390	8.50
4,800					361	8.00	289	4.00	323	6.00

VELOCITIES AND PENETRATIONS IN OAK.

GUN.	42-POUNDER, SEA-COAST GUN.				8″ SEA-COAST HOWITZER.	
Ball.	Shot, 43 lbs.		Shell, 32½ lbs.		Shell, 51½ lbs.	
Charge.	10½ lbs.		7 lbs.		6 lbs.	
Distance from Muzzle.	Velocity.	Penetration.	Velocity.	Penetration.	Velocity.	Penetration.
Yards.	Feet.	Inches.	Feet.	Inches.	Feet.	Inches.
0	1,600	58.37	1,600	44.34	1,150	35.18
600	1,174	39.52	1,078	26.50	858	22.60
1,200	894	26.64	764	15.84	651	14.56
2,400	557	12.15	426	5.67		

XI. *Extracts from Experiments made on the Penetration of the Projectiles of Rifled Cannon and Small Arms.*

A large number of experiments have been made in Europe on the comparative penetration of the projectiles of smooth bore and rifled guns into earthen parapets. In but few of the experiments, with rifled cannon of the heaviest calibre, have the depths of penetration into ordinary earth exceeded *twenty-two feet.* This arises from the deflection, from a rectilinear course, which the oblong rifle projectiles almost uniformly take, in their progress in the earth. It is only at comparatively considerable distances that the superiority of penetration of the oblong projectile from the rifled gun, over the spherical from the smooth gun, is very marked. Like conclusions, it will be seen, are drawn from experiments made on our side.

From experiments made in Belgium, in 1862, the penetration of the shot of a twenty-four-pounder smooth bore, fired with a charge of one-fourth the weight of the ball, into a mass of mixed earth, sand and clay, well rammed, at short breaching range, was twelve feet; whilst that from the shot of a rifled gun of the same calibre, fired with a charge one-twelfth the weight of the shot, was fourteen feet. In the same soil a sixty-eight-pounder spherical ball, fired with a charge of twenty-two pounds of powder, at a distance of 110 yards, penetrated somewhat over eleven feet.

At a distance of 880 yards, the spherical projectile of the twenty-four-pounder smooth bore, fired with the charge of one-fourth the weight of the ball, penetrated to the depth of seven feet, whilst the oblong ball of the same calibre, with a charge of one-twelfth the weight of the ball, penetrated 7.70 feet.

KIND OF PIECE.	PROJECTILE.	Charge.	No. of Shots.	Least penetration of new earth	Greatest penetration of new earth.	Mean penetration of new earth.	Mean penetration of natural earth.	Exploded.	Distance entered before explosion.	Depth of cavity after explosion.	Diameter of cavity after explosion.	REMARKS.
		Lbs.	No.	Feet.	Feet.	Feet.	Feet.	No.	Feet.	Feet.	Inches.	
100-pounder, Parrott..	Solid Shot..............	10	2	15	18	16½						See Diagram No. 1.
" " " ..	" "	10	1									" " Penetrated new earth 12 ft., and natural earth 5 ft. Total 17 ft.
" " " ..	Perc. Shell..............	10	4	10	16	13¾		0				See Diagram No. 1.
" " " ..	" "	10	1					1	11	3	30	" " "
30 " " ..	Solid Shot..............	3½	4	9	12	10¾						
" " " ..	" "	3½	1				3					
" " " ..	Perc. Shell..............	3½	1	12	12	12		1	3	9	24	
4½ inch Ordnance....	Hotchkiss Shell (filled).....	3½	1	6	6	6		1	not known.		not enlarged.	
" "	" " "	3½	1				4	1	not known.		not enlarged.	
" "	" " (not filled)..	3½	4	4	6	5						
" "	Schenkel Case Shot.......	3½	1	6	6	6		0				
" "	" "	3½	1				4	1	2	2	9	
" " ...	Schenkel Case Shot (powder removed).............	3½	2	8	9	8½						
" " ...	Schenkel Shell	3½	2	5	8	6½		1	3	2	9	
20-pounder, Parrott....	Solid Shot..............	2	6	3	10	8 1-6						
" " "	Perc. Shell..............	2	2	8	9	8½		1	3	5	14½	
10 " "	Shell (unfilled)...........	1	4	5	8	6½						
10 " "	" "	1	1									Penetrated new earth 3 feet, and the natural earth 2 feet. Total 5 feet.
10 " "	Perc. Shell....	1	4	5	10	6¼		0				
42 " "	Solid Shot (8½ lbs.)........	8	4	11	14	12¾						
42 " "	" " "	8	2				9½					
42 " "	" " "	8	1									Penetrated new earth 6½ feet, and the natural earth 9½ feet. Total 16 feet.
24 " Smooth Bore	Solid Shot..............	6	5	7	8	7 4-5						
24 " "	" "	6	1									Penetrated new earth 6 feet, and the natural earth 2 feet.

The foregoing table gives a summary of the experiments made, in 1863, at Battery Cameron, under the direction of Captain H. L. Abbott, U. S. Corps of Engineers, and Colonel 1st Connecticut Artillery, upon the penetration of shot into a butt of rammed earth, the range being 383 yards in each case.

DIAGRAM No.1.

100 PDR. PARROTT

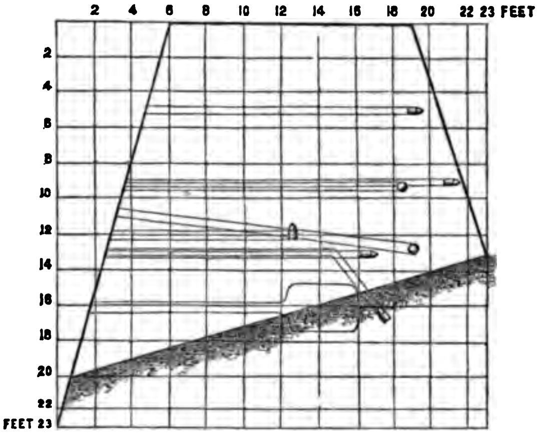


Diagram of the Penetrations of the Projectile of a 100-Pounder Parrott into made and natural earth. The side of each square on the Diagram is *two feet*.

In a report made to General Barnard, by Captain Abbott, June, 1863, on the penetration of shot into a soil of sand mixed with a little clay, the whole well rammed, and having been erected about eighteen months, Captain Abbott states as follows:

"My inferences from these and my former experiments, reported on May 1st, are the following:

"1st. The penetration of elongated rifle projectiles is very variable, depending on the axis of the shot. Where this remains parallel to the trajectory, they exceed those of smooth bore shot of corresponding weight by, at least, *one-fourth*, and this too notwithstanding the much smaller charges and less initial velocity. If the projectile turns, however, as a very slight obstacle, even a fascine, will compel it to do, the penetration is greatly reduced, sometimes nearly one-half. There is a marked tendency in the projectile to rise.

"2d. The Parrott percussion shell is admirable for blowing up magazines, as it does not burst until after at least three quarters of its penetration but its capacity must be greatly increased to do any damage to parapets. The Parrott time shell is not to be depended upon for this kind of service, the fuse being very liable to be extinguished.

"3d. As the velocities and consequently the penetrations of an elongated projectile diminish very gradually, it is not safe to depend upon less than *twelve feet* of well rammed earth of old parapets to render a plank magazine above ground secure; or at least *twenty feet* of fresh dug earth. Hence, in good soil there is an economy of labor in sinking magazines entirely below the surface of the ground. If this cannot be done, a covering of small logs or of fascines, laid over the exposed parts of the outside of the magazine, adds much to its security, by deflecting the projectiles, and thus reducing their penetration."

In the Journal of the siege of Fort Wagner, it is stated that, "the ricochet of the large shells from the smooth bore navy guns was uniform, and landed nearly every one in the Fort. That of the army rifled gun was irregular; most of them exploded when they struck, throwing up a great quantity of sand which falls back in its place, hence inflicting no injury but what may arise from the heavy jar."

A wide range of experiments was made at Magdebourg, in 1862, by a mixed commission of Russian officers of engineers and artillery, to ascertain the penetration of solid and hollow projectiles, of rifled, breech-loading, six, twelve, and twenty-four-pounder guns, and the explosive effects of the latter, in parapets and traverses of compact clay and sand. The ranges varying from 800 to 1100 paces. The following are the conclusions drawn by the commission from these experiments:

1st. That the accuracy of fire of rifled guns and the explosive effects of their projectiles, will enable earthen parapets the least favorable to the attack to be destroyed at great distances. Nevertheless, from the large expenditure of costly munitions which will be required for this purpose, the assailing party will but in rare cases attempt to breach parapets in this way. The defence having the means of repairing at night the damages done in this way by day will, with ordinary activity, have the advantage over the attack.

2d. In seeking from experiments the thickness which should be given to parapets, the explosive effects of the hollow projectiles should be taken as a base rather than their depth of penetration, because from the nature of the fuses employed, these projectiles explode before reaching their entire depth of penetration. On the other hand, the general use of time fuses of the kind tried presented great difficulties.

3d. In connexion with this subject, it may be added that as field fortifications have but a temporary object to subserve, and are rarely designed to offer a resistance to a fire of considerable duration; as they are moreover of hurried execution, and would require an expenditure of labor and time out of all proportion to any advantage that might accrue from a considerable increase of parapet, the rule of giving such works parapets of only from eight to twelve feet at the most may be safely adopted.

4th. Like considerations would prescribe twenty feet as the limit of the thickness of the parapet for permanent works generally. In cases, however, where great strength seems necessary and where the advantages of positions for the assailing batteries are very marked, it would be well to increase this thickness to twenty-four feet.

The points of the parapet where this increase of thickness would be most useful, are those which are on the prolongation of the terrepleins of the work and adjacent to the salients.

The best manner of doing this would be to raise the parapet at these points two or three feet, so as to bring the top of it on a level with the traverses and to give this raised portion a thickness of twenty feet. In this way a considerable extra thickness will be obtained at the original level of the exterior crest of the parapet, and the traverses will be better covered from the effects of shot fired with full charges to enfilade the terreplein.

5th. The traverses should be raised four feet above the general level of the exterior crest and made eight feet thick at top. In this way a considerable extra thickness will be obtained at the level that it was usual to give them, which was only two feet above the general level of the exterior crest.

To exceed this limit would encumber too much the terrepleins. Traverses, constructed on these rules, give great security against the plunging fire of projectiles of the heaviest calibre, as but small charges can be used in these cases, which diminish very much both the accuracy of the fire and the depth of penetration. From results of these experiments it may be stated, that the projectile of a twenty-four-pounder gun, with a range of from 1200 to 1300 paces, will strike the base of a traverse placed at twenty-five paces to the rear of another ten feet in height. This could not take place from a battery nearer than this distance; moreover, to strike the second traverse, at a point midway between the top and bottom the charge of powder should not exceed three pounds.

These results are of importance, from the void spaces which it is necessary, in many cases, to leave in traverses, since the position and the construction of these void spaces depend upon the depth of penetration. From these experiments it also results, that the bottom of the cavities in traverses, in giving them the usual dimensions, should be placed considerably below the level of the terrepleins of covered ways, to make them secure shelters.

6th. The parapets of trenches should receive a thickness such that they will not be penetrated at the level of six feet above the bottom of the trench, by the projectile of a twenty-four-pounder gun. As the depth of penetration of these projectiles is about fifteen feet, the normal width of the base of the parapet of the first parallel, which is sixteen feet, and the depth of the trench, are insufficient for safety; the depth of the trench and the thickness of the parapet should both be increased in this parallel.

In the Journal of the siege of Fort Wagner, an observation is made upon the expertness with which the besieged filled up the throats of their embrasures with sand bags, after each discharge of their cannon, so as to cover their cannoneers thoroughly from the fire of our sharp-shooters. The facilities with which repairs were made, by the besieged at Sebastopol, at night, of the damage done to their parapets by day—also, like facts of more recent occurrence in our own experience, and those observed at Fort Wagner, and in the preceding experiments, showing the comparatively slight real damage done by the explosion of hollow projectiles in earthen parapets, owing to a large portion of the lifted earth falling back into the crater, prove how difficult is the breaching of such parapets; and that but in few, and those very favorable cases, would the attempt to do so repay the cost of time and the expenditure of ammunition.

Results of Experiments made to ascertain the Penetration of the Elongated Projectiles of the Parrott Gun into Earth.

The butt in this case was formed of gravel mostly less than a quarter of an inch in diameter well rammed.

The range was 1000 yards.

For the solid projectiles of the twenty-pounder and thirty-pounder guns, the average penetration was three feet.

For the solid projectiles of the gun having a bore of six seven-sixteenths inches, weight of projectile eighty pounds, the average penetration was seven feet.

For the solid projectiles from the eight-inch gun, weight of projectile 150 pounds, the average penetration was eight feet.

In the report made to General Delafield, Chief Engineer, by Captain McAlester, Corps of Engineers, he states: "Observing the slight effects on the butt from the explosions of the hollow projectiles, and these explosions always took place backwards, apparently through the apertures formed by the shells in entering the parapets, it occurred to me that the effects might be increased by using time fuses which should burn long enough to allow the shell to reach its ultimate penetration."

Results of Experiments made at West Point by Captain Benét, *Ordnance Corps, upon the Penetration and Explosive Effects of the Projectiles of the Parrott Gun.*

The butt in this case was made from a mixture of sand and clay, free from gravel and compactly rammed; the mass being confined on the sides by a strong boarding placed vertically; the front and rear receiving the natural slope of the earth.

The range in all cases was twenty-four yards.

For the Parrott, twenty-pounder, with a charge of three pounds of mortar powder, the greatest penetration was nine and a half feet.

With a charge of two pounds of the same powder, greatest penetration eight and a half feet.

With percussion shells and a charge of two pounds of the same powder, the average penetration was about six feet, and craters were formed by the explosions of the shells having diameters of four and eight feet respectively, with depths of one and two feet respectively.

For the Parrott, thirty-pounder; weight of solid shot twenty-nine and a half pounds; charge from three and a quarter to four pounds of mortar powder; the average penetration was about ten feet.

With percussion shells weighing twenty-five and three-quarter pounds, and the same charges of the same powder, the penetrations varied from four and a half to thirteen and a half feet.

The craters from the explosions of these shells were from ten to twelve feet in diameter, and from two and a half to three feet in depth.

For the Parrott, 100-pounder, weight of solid flat-head shot and of elongated shell varying from eighty to ninety-six and a half pounds, with charges of ten pounds of Hazard's number five and seven powder, the penetrations were fourteen feet; with a charge of twelve pounds of number seven powder and weight of solid flat-head shot eighty-one pounds, the penetration was fifteen and a half feet; and with the same shot and a charge of twelve pounds of mammoth powder, the penetration was eighteen and a half feet.

A round thirty-two-pounder shot with sabot, the shot covered with cloth, fired from the same gun with a charge of twelve pounds of Hazard's number seven powder, penetrated ten and a half feet.

With long shells weighing from ninety-six to 100 pounds, fired with charges of ten pounds of Hazard's number five powder, the penetration was from twelve and a half to fourteen and a half feet.

An explosion from one of these shells gave a crater of twelve feet diameter and two feet depth.

For the Parrott eight-inch gun, weight of long shell 144 pounds, and of flat-head solid shot 150 pounds, charge of powder eighteen pounds, the penetration was from twelve and a half to eighteen and a half feet.

With long and short shells weighing from 142 to 146 pounds, with charges of powder from sixteen to eighteen pounds, the penetrations at the moment of explosion were from eight and a half to ten and a half feet; giving craters from twelve to seventeen feet diameter, with depths from one and a half to five feet.

From the results of a few trials made by Lieut.-Commander Jeffers recently at the Washington Navy Yard, with a twelve-inch gun rifled according to Parrott's plan; weight of shot 597 pounds; with a charge of thirty-five pounds of mammoth powder; range 200 yards; the penetration into a natural bank of clay, the face of which was cut down vertically, was thirty-one and a half feet.

XII. *Penetration of Rifled Projectiles from Small Arms into various Media.*

During the siege of Fort Wagner, the following results were obtained, from experiments made on the penetration of the projectiles of rifled muskets, at ranges from ten to fiften yards:

Dry yellow pine wood penetration from			2¼	to 8¼	inches.
Green palmetto	"	"	7½	to 8½	"
Dry fascines	"	"	8½	to 9½	"
Dry sand in bags	"	"	6	to 7	"
Wet " "	"	"	7½	to 8½	"
Loose damp sand	"	"	8	to 14	"
Cotton packed by hand in sand bags penetrated				22	"

The sand above referred to was a fine, light-colored quartz, weighing when dry eighty-six pounds to the cubic foot. It absorbs about three gallons of water per cubic foot, diminishing in bulk about one-twentieth, and then weighing 110 pounds per cubic foot.

Results of Experiments with the Royal Engineer, Lancaster Rifled Carbine. See Professional Papers of the Corps of Royal Engineers. Vol. VI. *New Series.*

Range	120	yards.	Greatest depth of penetration into yellow deal	6.5	inches.
"	"	"	Mean " " "	5.8	"
"	420	"	Greatest " " "	4.9	"
"	"	"	Mean " " "	4.22	"
"	120	"	Greatest " " fresh oak	2.94	"
"	"	"	Mean " " "	2.68	"
"	"	"	Greatest penetration of six-inch deal plated with sheet iron three-sixteenths of an inch thick	1.8	"
			Mean penetration of same	1.08	"

With same range, three-inch oak covered with same sheeting, the ball passed through the iron and penetrated the oak 0.3 of an inch.

Results of Experiments on the Penetration of Rifle Bullets into various Substances. See Professional Papers of the Corps of Royal Engineers. Vol. VII. *New Series.*

The arms used were the *Enfield* Rifle and the *Lancaster* Rifled Carbine.

Range	twenty	yards;	with Lancaster Rifle, the mean penetration into a parapet of light, sandy soil, rammed lightly, was	15	inches.
"	"	"	with Enfield Rifle, circumstances the same	15	"
"	"	"	Lancaster Rifle, mean penetration into solid oak	2.8	"
"	"	"	Enfield Rifle " " "	2.75	"
"	"	"	Lancaster Rifle, mean penetration into two thicknesses of three inch oak	8.0	"
"	"	"	Enfield Rifle, mean penetration into two thicknesses of three inch oak	8.58	"
"	"	"	Enfield Rifle, penetration into solid pine, *with* the grain	9.83	"
"	"	"	Lancaster Rifle, penetration into sand bags, filled with light, sandy earth, and formed as a parapet	all stopped.	
"	"	"	Enfield Rifle, one bullet passed through a stretcher.		
"	"	"	Lancaster Rifle, penetration into a sap roller four feet exterior diameter; 2.5 feet interior diameter; nine inches thickness of fascine stuffing	9	inches.
			Enfield Rifle same penetration as Lancaster Rifle.		
"	"	"	Lancaster Rifle, penetration into fascines, nine inches diameter, of green wood, backed by earth. Through the fascine and into the earth	7	"
			Enfield Rifle, same circumstances	8	"
"	"	"	With Gabions of both brushwood and sheet iron, filled fresh with light sandy earth, the bullets of neither arm passed through		
"	fifty	"	It required a rope mantelet, like those used at the siege of Sebastopol, consisting of three vertical and two horizontal layers of four and a half inch rope, weighing twenty-seven and a half pounds to the square foot, to give full protection against the bullets of each arm.		

From Experiments made on iron plates of various thicknesses it was found, that a homogeneous plate, three-sixteenths of an inch thick, and weighing seven and five-twelfth pounds per square foot, gave security against the bullets of both arms, at ranges varying from twenty yards to 200 yards.

Boiler plates of a quarter of an inch thick, and nine five-sixth pounds to the square foot, were found not to be proof against either arm at a range of 200 yards.

Steel-pointed bullets were found to give slightly better results than the bullet of lead alone.

FIELD FORTIFICATION.

CHAPTER I.

GENERAL PRINCIPLES AND NOMENCLATURE.

1. WHEN an armed force is constrained to act on the defensive, either from inferiority in numerical strength or discipline to its adversary, it should endeavor to counterbalance this disparity against it by selecting a position on which to receive battle, which will afford every military advantage to itself, and prove, in a corresponding degree, unfavorable to the assailant.

2. **General Conditions.** A defensive position to afford these advantages should satisfy the following conditions:

1. It should present natural obstructions to the advance of the assailed, so as to deprive him of the advantage which his superiority in numbers or discipline would give him in a hand to hand conflict.

2. The features of the ground should screen the assailed from the assailant's view, and offer covers from the assailant's fire, whilst their own fire can be used with full effect.

3. It should command or overlook the ground over which the assailant will be obliged to advance, in such a manner that its surface will be swept by the fire of the assailed.

4. In like manner all the lines of approach of the assailant should be swept not only by the front, but the cross fire of the assailed.

5. It should offer no obstructions to the free movements of the assailed either for the offensive or defensive, and afford facilities for active offensive movements at the opportune moment.

6. It should have secure natural points of support both on its flanks and in the rear.

7. It should afford every convenience for encamping and supplying the army.

8. Its lines of retreat should be ample and secure.

3. As natural defensive positions, offering all or even the most essential of these advantages, are seldom met with, their defects have to be remedied by artificial means. These means from their object have received the name of *fortification*.

4. Fortification may therefore be defined as *the art of so arranging a position selected for defence that an inferior force shall be able to resist with advantage the assaults of one superior to it.*

If the artificial means are of a durable character, and the position is to be permanently occupied, the works receive the name of *Permanent Fortification;* but when the position is to be occupied only for a short period, or during the operations of a campaign, perishable materials, as earth and wood, are mostly used, and the works are denominated *Temporary* or *Field Fortification.*

5. The term *Intrenchments* or *Lines* is applied to fortifications of considerable extent, thrown up to cover an entire army or an army corps on the front and flanks. A position so fortified is said to be *Intrenched.*

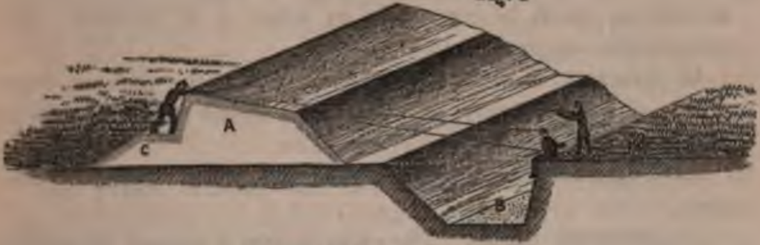
6. The term *Field Work* is applied to a fortification of limited extent, to be occupied by a small isolated detachment dependent upon its own means of resistance.

7. Fortifications should be regarded only as an accessory defensive means, but still a very important one, and they will conduce to the end proposed, the more nearly they are made to satisfy the foregoing conditions of a strong defensive position.

8. To satisfy the first three of these conditions, viz.: to offer an obstruction to a hand-to-hand conflict; to shelter the assailed from the view and fire of the assailant; and to afford the assailed a commanding view and a sweeping fire over the assailant's lines of approach; fortifications must consist of a covering mass of earth, stone, wood, or iron, of sufficient height and thickness to screen the men behind it from view, and to intercept the missiles of the assailed, and of some obstruction in advance of it which will prove a serious obstacle in the way of the assailant's advance.

9. Parapet. The covering mass (Fig. 1) is termed a *parapet* when it fulfils the last two of these conditions; when intended simply as a screen, as in the case of a cover for cavalry when waiting to be brought into action, it is termed an *epaulment;* and

Fig. 1



A Parapet; B Ditch; C Banquette.

when used to cover troops from an enfilading fire on the flank or in the rear, a *traverse.*

10. Ditch. The most usual obstruction to impede the enemy's advance to attack with the bayonet, is a *ditch* placed in front of the parapet. When the parapet is of earth, the ditch furnishes the material for its construction.

11. Banquette. When the parapet is too high to admit of a man standing on the natural level of the ground to fire over it, a platform of earth or wood is placed behind it, from which the soldier can fire at the proper level. This is termed a *banquette.*

Fig. 2

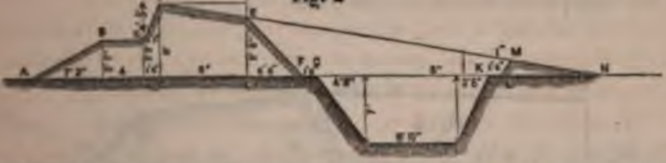


Fig. 2. This Fig. shows the ordinary form of the Profile of an Intrenchment, in soils of which the Natural Slope is one perpendicular to one base.

A B C D E F is the profile of the Parapet.
G H I K the profile of the Ditch.
L M N the profile of the Glacis.
A B is the Banquette Slope.
B C Tread of the Banquette.
C D the Interior Slope.
D E the Superior Slope.
E F the Exterior Slope.
F G the Berm.
G H the Scarp.
H I the Bottom of the Ditch.
I K the Counterscarp.

A the foot of the Banquette Slope.
B the Crest of the Banquette.
C the Foot of the Interior Slope.
D the Interior Crest.
E the Exterior Crest.
F the Foot of the Exterior Slope.
G the Crest of the Scarp.
H the Foot of the Scarp.
I the Foot of the Counterscarp.
K the Crest of the Counterscarp.
M the Crest of the Glacis.
N the Foot of the Glacis.

12. Banquette Slope. (Fig. 2.) When the top surface of this platform, termed the *banquette tread*, is too high to be reached from the ground by an ordinary step, a ramp, either of earth or timber, is placed in rear of it, by which it is reached. This ramp is the *banquette slope.*

13. Interior Slope. The interior face of the parapet, when arranged for musketry, is termed the *breast height* or *interior slope;* when for artillery the *genouillère.*

14. Superior Slope. The top of the parapet is the *superior slope.*

15. Exterior Slope. The exterior face is termed the *exterior slope.*

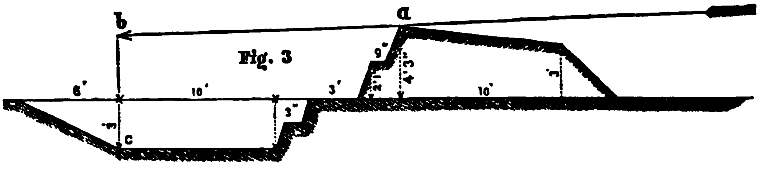
16. Berm. Between the parapet and ditch a narrow zone is usually left on the natural surface of the ground which is termed the *berm.*

17. Scarp and Counterscarp. The side of the ditch adjacent to the parapet is termed the *scarp;* the side opposite to this, the *counterscarp.*

18. Glacis. A mound of earth placed in front of the counterscarp with a gentle slope outwards, is termed a *glacis.*

19. Trench. To obtain speedy cover, the parapet (Fig. 3) is formed from a ditch within, termed a *trench,* of sufficient depth, with the height of the parapet, to give shelter to the troops when standing in the trench. The natural ground serves as the banquette tread in this case.

Fig. 3



A Parapet; B Trench; C Banquette Tread.

20. The measures taken for the attack and defence of fortifications have an interdependence so intimate that the dispositions made by the one party naturally control those that the other may make. The assailing force naturally seeks to advance on those points which offer the least obstruction, either by their passive strength or by the fire which sweeps the ground over which the advance has to be made. The most favorable case for the assailant will be where no fire from the assailed sweeps over

the ground along which he advances; the next is where, although the missiles of the assailed sweep above the approach, they pass so high above the assailant as to inflict no injury.

21. Sector without fire and Dead Angle. Where the first case occurs, the ground free from fire is termed a *sector* or *zone without fire.* The second is termed a *dead angle* or *dead space.*

22. Front, Flank, and Cross Fire. In planning or disposing fortifications in relation to the position to be defended, it is very important that the parts shall be so distributed as to obviate these two defects, besides satisfying the other general conditions already laid down, which are to bring a *front, flank,* and *cross fire* upon the assailant's column of attack; or, in other words, one sheet of fire that will sweep the column from front to rear, another to bear upon each of its flanks so as to cross their fire with each other and with the one from the front. In this way mutual defensive relations are sought to be established between all the parts.

23. Flanked Disposition. To effect this, certain parts are thrown forward towards the enemy, to receive his attack; they are denominated *advanced parts;* other portions, denominated *retired parts,* are withdrawn from the enemy, and protect by their

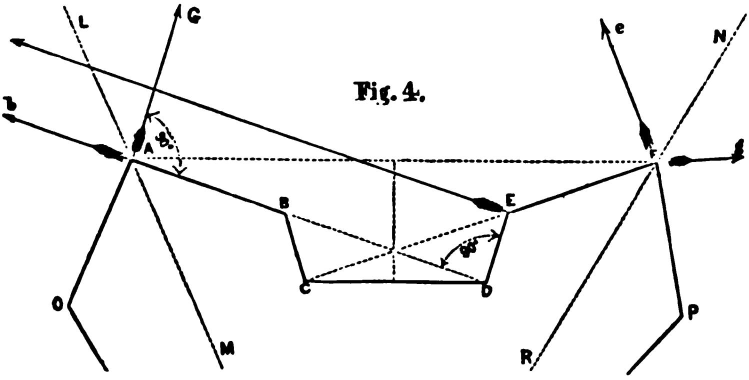


Fig. 4.

Fig. 4. General Plan of Intrenchments with Flanking Arrangements.

O A B and E F P are the Advanced Parts.
B C D E are the Retired Parts.
A O, A B, E F, and F P are the Faces.
B C and D E are the Flanks.
C D the Curtain.

A D and C F the Lines of Defence.
O A B and E F P are the Salient Angles.
B C D and C D E the Re-entering Angles.
A D F and B C F the Angles of Defence.
b A c and e F g the Sectors without Fire.

L M and N R the Capitals.

fire the advanced parts. This arrangement naturally indicates that the general outline of the plan must present an angular system; some of the angular points, denominated *salients*, being towards the enemy; and others, denominated *reënterings*, towards the assailed.

When such a disposition is made, it is denominated a *flanked disposition;* because the enemy's flank is attained by the fire of the retired parts when he is advancing upon the salients.

A flanked disposition is shown in Fig. 4. The advanced parts are denominated *faces;* the retired parts, which protect the faces, the *flanks;* the retired part connecting the flanks is the *curtain.*

The angle formed by two faces is denominated a *salient angle*, that formed by two retired parts, a *re-entering angle;* and one made by a face and the opposite flank, an *angle of defence.*

The line bisecting a salient angle is denominated the *capital*, the distance from a salient to its opposite flank is a *line of defence.*

CHAPTER II.

FIELD WORKS ON A HORIZONTAL SITE.

24. Site, Command, Relief. The ground occupied by a work is denominated the *site*, or *plane of site*.

The *command* is the height of the interior crest above the site; and the *relief* is the height of the same line above the bottom of the ditch.

25. Direct, Slant, Enfilading, Reverse, and Cross Fire. A fire is said to be *direct*, *slant*, or *enfilading*, according as its direction is perpendicular to, makes an angle of 30° with, or is on the prolongation of the line at which it is aimed; when the line is taken in the rear the fire is denominated a *reverse fire;* and when a given space is defended by the fire from several points crossing over it, the defence is denominated a *cross fire*.

26. Relations of Parts in Flanked Dispositions. In planning a work the interior crest is regarded as the directing line in regulating the dimensions of the faces, flanks, etc., because this line shows the column of fire for the defence. There exists a necessary subordination between the plan, relief, and command of works, which prevents the dimensions of the one being regulated independently of the others; but, without entering into a close examination of this necessary co-relation of the parts, it may be stated generally, that faces should vary between thirty and eighty yards, flanks between twenty and forty yards, and curtains should not be less than twelve times the relief.

In establishing the co-relations between the different parts of any isolated works or combination of the elements of field fortification, the following rules should, as far as practicable, be observed:

I.

A flanked disposition should be the basis of the plan of all intrenchments.

The flanks sweep with their fire the ground in front of the faces; remove sectors without fire and dead angles; cross their fire in front of the salients; and take the enemy's column in flank.

II.

Every angle of defence should not be less than 90°, *or greater than* 110°.

An acute angle of defence exposes the faces to the fire of the flanks; a too obtuse angle leaves a portion of the ground in front of the face undefended.

In the heat of action the soldier, from his position behind the parapet, naturally brings down his piece, in the act of firing, in a position sensibly perpendicular to that of the interior crest. If every bullet, therefore, took this direction, those delivered just exterior to the parapet flanked would barely clear the men drawn up along it. On this account, and from the fact that unless checked before reaching the ditch the success of the assaulting column is greatly assured, it is better in field works to make the angles of defence so open that all the fire of the general defence from the flanks shall be thrown from just within the counterscarp outwards; and to insure the flanking of the ditches by cannon, or a body of infantry specially detailed for this duty.

III.

A line of defence should not exceed 160 *yards for the ordinary smooth-bore musket, nor over* 300 *yards for the rifled musket.*

The lines of defence should be based upon the skill in handling their weapons of infantry in an ordinary state of efficiency, and allowance must also be made for the ordinary range of distinct vision of such men. The fire of the smooth-bore, with troops in this state, is very effective at 160 yards; and with the best weapons, the fire of none but well-trained and special troops can be depended upon much over 300 yards. Particular cases may require the lines of defence to exceed this limit. When they arise, they should be specially provided for. The shorter the lines of defence, where the flanking dispositions are good, the longer will the assailant be exposed to the fire of the assailed before he can attain the works, and the greater the chances of checking him.

IV.

A salient angle should not be less than 60°.

A salient less than 60° is too weak to withstand the effects of weather; the interior space which it incloses is too confined for the manœuvres of the troops; when its faces are not flanked, there will be a large sector without fire in front of it.

The positions which the assailed can take up to enfilade either face of an acute salient are more favorable to him than in that of an obtuse one, as his guns are thrown farther from, and are exposed to a less direct fire of the adjacent face of the salient, and of any other parts of the fortification adjacent to this face. This rule, however, should not be taken as absolute, as many cases may arise where more acute salients can alone be obtained, and in which the troops being restricted to a passive defence, will require only room enough to load and fire either cannon or muskets. As such salients are necessarily very weak, the approaches to them should be obstructed by every means at hand.

V.

A strong profile is essential to a vigorous defence.

The rapidity with which a column of attack approaches, and the short time it remains exposed to the fire of the work, unless detained by obstacles in front of the ditch, render its loss, generally, so trifling as not to check its march until it arrives at the crest of the counterscarp. Here, if the ditch is deep, some delay ensues in entering it, during which the column is exposed to a warm fire within short range. When the ditch is entered, a more serious obstacle remains to be encountered, in the additional height of the parapet and scarp; and when this obstacle is overcome, the enemy presents himself in a fatigued and exhausted state to the bayonets of the assailed, who have mounted on the top of their parapet to meet and drive him back into the ditch.

This rule is essential in all isolated works where, from the small size of the garrison, the defence must necessarily be of a passive character, being restricted to a simple repulse of the assailant.

VI.

The work should be defended with the bayonet, and to the last extremity.

Unless the assailed are determined to meet the enemy at the point of the bayonet, they must evacuate their work so soon as he has entered the ditch; a longer delay to retreat would be followed by the most disastrous consequences.

The results of innumerable actions prove that the defence with the bayonet is the surest method of repelling the enemy. The assailed, having now become the assailant, are assisted by that moral effect which is produced by a change from a defensive to an offensive attitude. They have moreover the advantages of position and freshness over a climbing and exhausted enemy.

27. Classes of Field Works. Field works may be classified under three heads.

1st. Those which being secure on the flanks and in the rear, are assailable only in front.

2d. Those which are assailable in front and on the flanks.

3d. Those which are assailable on all sides.

28 First Class. The plan of the works of the first class, when the front to be defended is of very limited extent, may be a simple *right line.* From this line only a front or direct fire can be brought to bear on the assailant in his advance; and when he attains the ditch, the fire of the parapet passing over his head, he is in a sheltered dead space where he can leisurely take his measures to assault the parapet. For extended fronts a flanked disposition more or less perfect can be obtained, from which cross, as well as direct fire, can be brought to bear on the advance of the assailant. The most simple combination for this object is the *Crémaillère* or *Serrated Line* (Fig. 5), which consists of a broken line formed of long and short branches perpendicular to each other. The salient angles are protected by a cross-fire, as well as a portion of the ditch in front of the salients; but the portion of the ditch at each reëntering angle is a dead space, not being reached by the fire of the parapet.

Fig. 5.

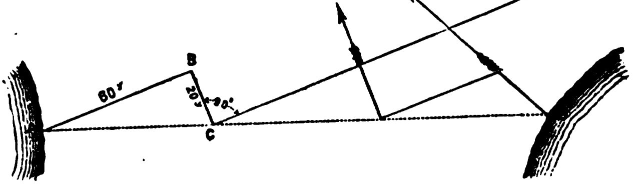


Fig. 5. Plan of the Crémaillère, or Indented Line.

29. Second Class. The plan of the works of the second class admits of great variety, depending on the extent of the position. The most simple is that of a work of two faces only, the salient being towards the assailant's line of approach. This work (Fig. 6) is termed a *redan*. Its faces should receive a direction such as to sweep the approaches to the flanks of the position. From the angular point but a single line of direct fire can be brought to bear on the sector in advance of it, and when the salient is 60° or less, only a very oblique fire from the faces can be brought upon this sector, which becomes thus a sector without fire for the assailed. To remedy this, a portion of the salient is filled in so as to form a short defensive line perpendicular to the capital. This line is termed a *pan-coupée*, and gives a direct fire in the direction of the capital prolonged outwards.

Fig.6

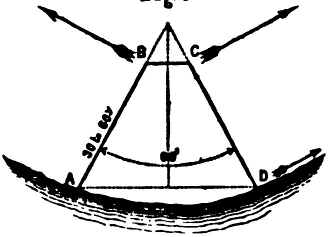


Fig. 6. Plan of the Redan.
A B and C D are the Faces. A D is the Gorge, or Gorge Line.
B C is a Pan-Coupée.

When the faces of the redan cannot be so placed as to sweep well the flank approaches without making the salient angle too acute; or when the flank approaches extend towards the rear; then the plan may, in the first case, be what is termed a *priest-cap* or *swallow-tail* (Fig. 7), in which the two main faces sweep

Fig.7

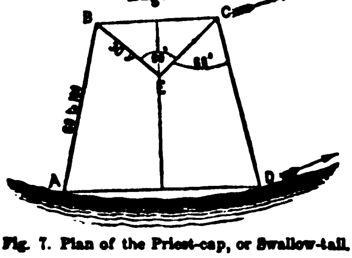


Fig. 7. Plan of the Priest-cap, or Swallow-tail.

the flank approaches, and, instead of a *pan-coupée*, a broken line forming a reëntering angle, placed in the salient, affords a cross-fire on the ground in front.

In the second case a flank is added to each face of the redan, and receives such a direction as to sweep that portion of the flank approach which cannot be reached from the faces except by a very oblique fire. This work is termed a *lunette* (Fig. 8).

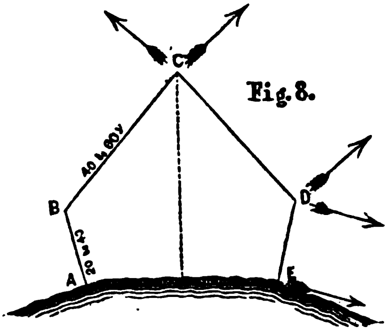


Fig. 8. Plan of the Lunette.
B C and C D are the Faces. A B and E D the Flanks.

30. Third Class. The works comprised in the third class are termed *enclosed works*, as, being assailable on all sides, they must, for security, present an unbroken line to the assault.

These works may also be divided into three classes: 1st. *Polygonal works* or *redoubts;* 2d. *Tenailled works* or *star forts;* 3d. *Bastioned works.*

31. Redoubt. A redoubt may be a polygonal figure of any number of sides, and when the site is horizontal, or sensibly so within the range of cannon, there is no reason for adopting any but a regular polygon for the plan. The most simple and the

Fig. 9.

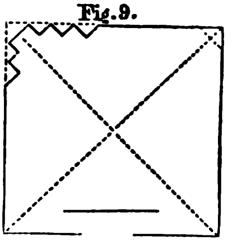


Fig. 9. Plan of the Square Redoubt, with the faces at one angle indented, and at the other arranged with a pan-coupée.

most usually taken is the square (Fig. 9). The redoubt is named after the polygon assumed for its plan.

The redoubt has sectors without fire at all its angles; and its ditch is a dead space throughout. To remedy, to some extent, the first defect, the salients may be arranged with *pan-coupées*. The second can only be removed by defences in the ditch and exterior to the parapet.

31. Star Forts. Star forts in plan consist of a polygon having alternately salient and reëntering angles. The object of this disposition is to obtain cross-fires on the approaches upon the salients, and to remove the dead space in the portions of the ditch at the salients. This can only be effected in star forts having at least eight salients. In all other cases, when the salients are limited to 60°, the reëntering angles become too obtuse to admit any but a very oblique fire from the faces in the direction of the salients.

The star fort is sometimes planned by placing redans on the middle of the faces of a square redoubt (Fig. 10), thus giving alternate salients of 90° and 60°. In some cases (Fig. 10) the salients of 90° are reduced to 60° by prolonging inwards the faces of the redans. When the site is horizontal there is no good reason for making the work irregular in its parts.

Fig.10.

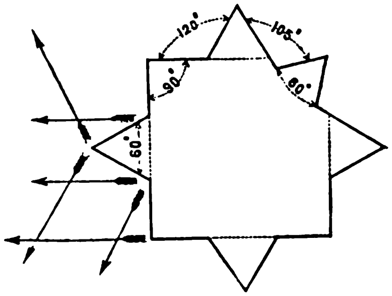


Fig. 10. Plan of Star Fort for a polygon of eight sides.

The star fort, from its imperfect flanking dispositions, is but little if at all superior in strength to the redoubt. For the same interior space for the uses of the garrison, the star fort presents a much longer line of parapet than the redoubt, to be defended. It is therefore only on irregular sites, or broken ground, that an application will be found for it.

32. Bastioned Forts. The bastioned fort has been devised to remedy the defective flanked dispositions of the preceding classes of works.

The bastioned fort may consist of a polygon of any number of sides; but for field forts, the square and pentagon are generally preferred, owing to the labor and construction. To plan a work of this kind, a square or pentagon (Fig. 11) is laid out, and the sides bisected by perpendiculars; a distance of one-eighth of the side is set off on the perpendiculars in the square, or one-seventh in the pentagon; from the angular points of the polygon, lines are drawn through the points thus set off; these lines give the direction of the lines of defence; from the salients of the polygon distances, equal to two sevenths of the side, are set off on the directions of the lines of defence, which give the faces; from the extremity of the faces, the flanks are drawn perpendicular to, or making an angle of 110°, with the lines of defence; the extremities of the flanks are connected by the curtains.

Fig. 11.

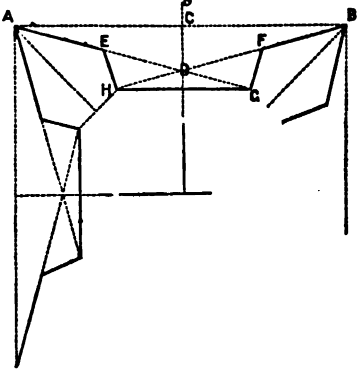


Fig. 11. Plan of a Bastioned Fort, constructed on a Square.
A B is the Exterior Side. A the Salient Angle.
C D the Perpendicular. E the Shoulder Angle.
H the Angle of the Curtain.
Note.—The nomenclature of the other parts is the same as in Fig. 4.

The side of the polygon is termed the *exterior side*; the line bisecting it, the *perpendicular*; the angle at the salient is the *flanked angle*; the one between the face and exterior side, *the diminished angle*; the one formed by a face and flank, the *shoulder angle*; the one between the flank and curtain, *the angle of the cur-*

tain; the portion of the work included between the capitals of two adjacent bastions is denominated a *bastioned front*, or simply a *front*.

An examination of the arrangement of a bastioned front will show that there are neither dead angles nor sectors without fire; that the salients, and all the ground within the range of fire, are protected by formidable columns of direct, flank, and cross-fire. There is one point in this system that demands particular attention, which is, that the counterscarp of the ditch, if laid out parallel to the interior crest, would form a dead angle along each face near the shoulder; because the fire of the flank would be intercepted by the crest of the counterscarp. To prevent this, either the counterscarps of the faces must be prolonged to intersect, and all earth between them and the scarp of the flanks and curtain be excavated (Fig. 12), or the ditch of each face must be inclined up in a slope from the bottom, opposite the shoulder (Fig. 13), so that it can be swept by the fire of the flank.

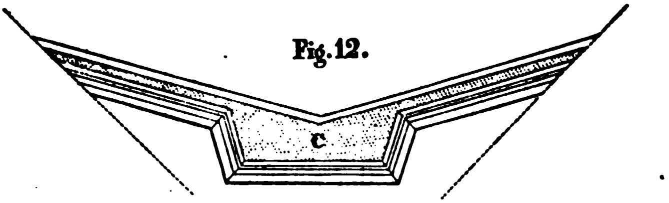


Fig.12.

Fig. 12. Plan of a Bastioned Front, with the entire ditch excavated in front of the curtain c.

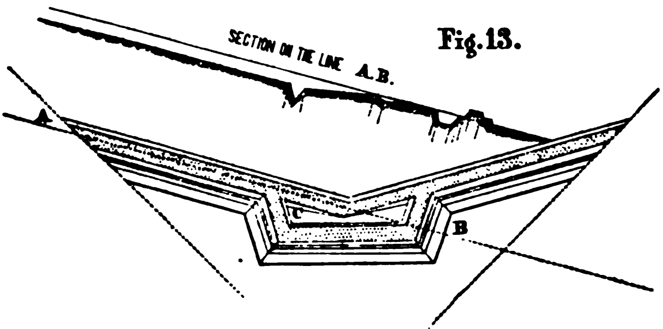


Fig.13.

Fig. 13. Shows the same with the ditches of the faces prolonged upwards to c in a slope. This arrangement will be best understood from the Section Fig. 13.

The first method is the best, but requires most labor; the

gives an easy access to
vantage of in an assault. It
second ditch at the foot of
feet wide, and about six
the bottom, and to plant a row
rough the flank (Fig. 13) shows

half bastions, but, being very
and much more difficult of con-
be used.

stion fort should not exceed 250
ards, otherwise the flanking arrange-
musket in the former case, and the
will be imperfect. With a relief
the greatest that, in most cases, can
an exterior side of 250 yards, the
be perfectly swept by the fire of the
will be nearly 180 yards, a length
defence, and the flanks will be nearly
of fourteen feet, the least that will
to an assault, and an exterior side of
the curtain will be well flanked, the
twenty yards in length, and the faces
ty yards. Between these limits, the
side must vary with the relief.

Field Works. The defence of enclosed
every point of the parapet should be
ment of assault, either by cannon or mus-
may be drawn up for the defence either in
ranks; and there should, moreover, be a
to the importance attached to the work.
ace, denominated the *terre-plein*, or *parade*,
great to lodge the troops, with the cannon
and will therefore depend on the nature of
llowing data will aid to regulate this point.
ccupy one yard, linear measure, along the
each cannon from five to six yards. The
each man is one and a half square yards;
square yards should be allowed for each gun.
an allowance must be made for the *traverses*,

to cover an outlet, to screen the troops from a reverse, or an enfilading fire, &c.; and for powder magazines, when they are not placed in the traverses. The area occupied by a traverse will depend on its dimensions, and cannot be fixed beforehand; that allowed for a magazine for three or four cannon may be estimated at fifteen or twenty square yards.

34. Character of Field Works. As a field fort must rely entirely on its own strength, it should be constructed with such care that the enemy will be forced to abandon an attempt to storm it, and be obliged to resort to the method of regular approaches used in the attack of permanent works. To effect this, all the ground around the fort, within the range of cannon, should offer no shelter to the enemy from its fire; the ditches should be flanked throughout; and the relief be so great as to preclude any attempt at scaling the work.

CHAPTER III.

INTRENCHMENTS OR LINES ON A HORIZONTAL SITE.

35. Classes of Lines. There are two classes of lines—*Continued Lines*, and *Lines with Intervals.* Continued lines present no openings through which the enemy can penetrate except the ordinary outlets. Lines with intervals consist of detached works, which are enclosed partly, or entirely, throughout their perimeters, arranged in defensive relations with each other; and presenting wide intervals between them defended only by their fire.

The same general principles apply to lines as to other field works; but from their great extent, they usually receive a slight relief, and the simplest angular figures are adopted for their plan. In laying them out, the engineer should avail himself of all the natural features presented by the position, so as to diminish the labor of erecting artificial ones.

36. Redan Line. The simplest arrangement for a continued line, consists in a series of redans (Fig. 14) connected by straight curtains; it is termed the *redan line.* The faces of the redans are sixty yards in length; their salient angles 60°; and the distance between their capitals 180 yards.

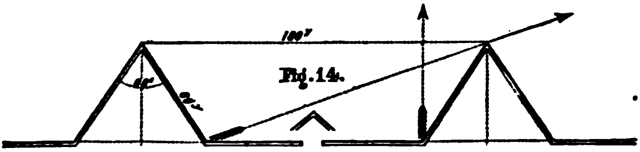


Fig. 14. Plan of a Redan Line, with a passage, A, in the curtain, covered by a small redan.

This combination will place the salients at 160 yards from the collateral reënterings. An inspection of this system shows that the ditches are not flanked; that the salients are not well protected, owing to the cross-fire leaving a considerable sector without fire in front of them; that the curtains, which, from their position, are the strongest points, are the best defended, and in turn they afford no protection to the faces. All these defects become more sensible as the redans are placed farther apart.

37. Tenaille Line. To remedy the defects of the redan line, it has been proposed to break the curtains forward (Fig. 15), so as to form two branches, one perpendicular to the face of each redan. This suggestion has led to the *tenaille line*, which consists of a combination of small and large redans, or simply of redans of the same size, forming salient and reëntering angles. This combination is superior to the redan line. The salients are protected by a cross-fire, and the ditches of the large redans are partially flanked; moreover, it presents fewer assailable points, on a given front, than the redan line; and its retired parts afford good positions for artillery.

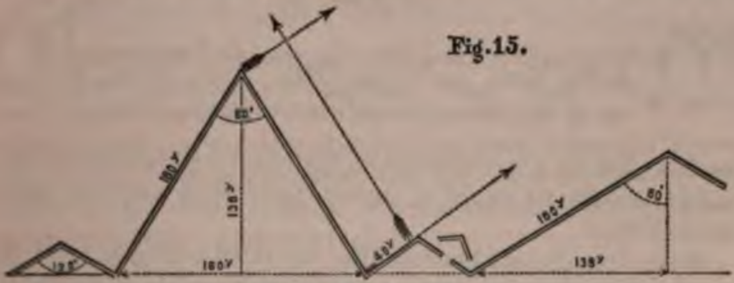


Fig.15.

Fig. 15. Plan of a Tenaille Line.

The faces of the large redans should not exceed 160 yards; and their salient angle should not be less than 60°. The faces of the small redans should not be greater than forty yards, and should be nearly perpendicular to those of the large redans. These combinations will give two limits for the length of the capitals of the large redans, and for their distance apart. When the salient angles are 60° the length of the capitals will be about 138 yards, and the distance between them 228 yards. When the salient angle of the small redan is 60°, the capitals of the large redans will be eighty yards long, and the distance between them 316 yards. In the first case there will be a greater number of assailable points on a given front, but the reënterings will be the stronger; in the second case the reverse of this will happen. Of course the size of the redans will not be restricted to the limits here laid down. This system is defective, in presenting long faces to an enfilade fire, and in taking up a considerable depth of ground, from the salients to the reënterings, which restricts its application to particular localities.

37. Serrated Line. The *serrated line* (Fig. 16) is principally used in place of a straight curtain between two advanced works, which are too far apart to protect each other and the space between them.

Fig.16.

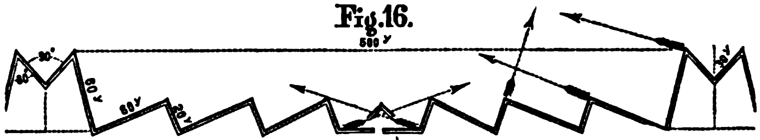


Fig. 16. Plan of a Crémaillère Line between two salient priest-caps.

When the ground between the advanced works is level, or nearly so, the branches of the crémaillère form salient and reëntering angles, which are on the same right lines. The long branches alternate from the middle point, where either a salient or reëntering angle is formed; the latter is preferable, as it is stronger, and may be arranged with flanks and a curtain, which will be better situated for defence than the two faces forming a salient angle.

38. Bastioned Lines. Owing to the imperfect flanking arrangements of the preceding systems, it has been proposed to use bastion lines. They are laid out by placing the salients 250 yards apart, and making the perpendicular of the front equal to one-sixth.

Fig.17.

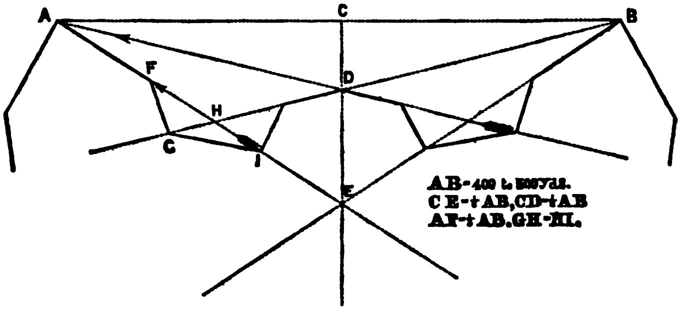


Fig. 17. Plan of a Bastion Line with double flanks.

Another arrangement of the bastion line is the one termed *with double flanks* (Fig. 17). The salients, in this case, should be between 400 and 500 yards apart. The figure explains itself. By this arrangement there are fewer assailable points on the same front; one of the bastions is placed in a strong reëntering; and the salients of the advanced bastions are protected by the flank fire of the collateral advanced bastion, and also of the retired bastion.

The principal objection to the bastion line is its great development, and the consequent increase of labor and time for its construction.

This objection, however, does not apply to a front of limited extent where the flanks of the line rest upon natural features like unfordable water-courses, or an impassable marsh which will prevent the line from being turned.

Continued lines are not suited to an active defence; and this is a grave objection to their use. Moreover, from the great dissemination of the troops over a long defensive line, the resistance at all points will be weak, and if one point is carried the rest of the line is taken in flank. Besides, the main reserve being at the centre, the flanks may fail to receive timely succor if attacked. The enemy, if repulsed by their fire, can retreat in good order, and renew the assault at a more opportune moment; because the assailed, if they attempt a sortie, must defile through narrow outlets, and present a feeble front to the enemy during the operation of defiling. They are, however, the best defensive means for irregular troops, owing to the confidence which they inspire. They also serve to guard against a surprise, and to prevent the predatory excursions of small detachments of the enemy.

39. Lines of Detached Works. The detached works used for these lines may be either lunettes or square redoubts (Fig. 18); their salients are 250 yards apart, and their salient angles may usually be 90°. The faces about sixty yards, and the flanks about forty yards, are so arranged as to sweep the ground in front of the salients of the collateral works. In the rear of the first line, and opposite to the intervals, redans are placed to flank the faces of the first line ; the faces of the redans may be about thirty yards. About 200 yards in the rear of the first line, and opposite the lunettes, cavalry epaulments are thrown up, to cover squadrons of cavalry to act on the flanks of the enemy, when his columns are shaken by the fire of the works.

The works of the first line are large enough to contain from 300 to 400 men, with a field battery in each, for their defence.

Fig. 18.

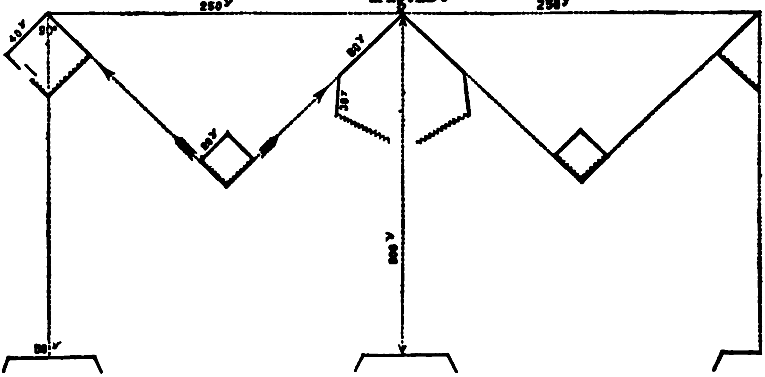


Fig. 18. Plan of a Line with Intervals of lunettes, or square redoubts, flanked by retired redans; with cavalry epaulments in rear.

The redans are good positions for batteries to flank the first line. Redoubts present an advantage over lunettes, because they are equally strong throughout, but this is accompanied by the defect that their rear faces may be used against the assailed if the enemy should carry them. The gorges of the lunettes should be enclosed by an abattis, palisading, &c., which will not afford a shelter to the enemy should he get possession of them.

40. Rogniat's Line. A system of defence has been proposed by General *Rogniat*, former *Chief* of the *French Engineer Corps*, in his work *Considérations sur l'art de la Guerre*, the spirit

Fig. 19.

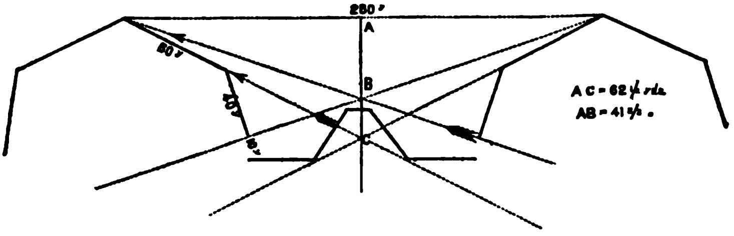


Fig. 19. Plan of *General* ROGNIAT'S Line.

of the arrangement of which partakes both of the bastion line with double flanks, and of the line with intervals.

Points 250 yards apart (Fig. 19), are taken for the salients of the lunettes; their faces and flanks are placed in defensive relations; and between them a redan, with a pan-coupèe, is placed to flank the faces, without intercepting the fire of the flanks; a straight curtain is carried from the redan, and leaves an interval of ten yards between it and the flanks of the lunettes for sorties.

With regard to the profiles, the lunettes receive the minimum profile both for the parapet and ditch. The redans are simple epaulments to cover cannon fired in barbette; and the curtains consist of a trench with the earth thrown in front to form a parapet, which is so arranged that the infantry may march from the trench in order of battle over it.

The advantages claimed for this system are, *first*, the short time required to form the works, by which an army may entrench its field of battle in one night; *second*, the lunettes form the first line of the order of battle, and contain only infantry, and the batteries are placed in the redans, where they are more secure, protect the lunettes, and withdraw the fire of the enemy's artillery from the lunettes; *third*, the curtains are defended by infantry, who can sally from them at a moment's warning, and aided by the light artillery and cavalry, who débouche through the intervals between the curtains and lunettes, and attack the enemy in flank. If the flanks of his position are not secured by natural obstacles, Gen. Rogniat proposes to throw up towards the rear a strong square redoubt on each flank, and to place a heavy battery in the interval between the redoubt and the adjacent lunette.

Lines with intervals are peculiarly adapted to well disciplined and active troops. The works thrown in advance constitute the first line of the order of battle, against which the first shock of the enemy is partially thrown away, and he dare not attempt to neglect them, for an endeavor to penetrate through the intervals would expose his flanks to a close and deadly cross-fire. If the enemy is repulsed, the main body of the army, which is drawn up in rear of the works, immediately assumes the offensive, and, by a vigorous advance movement, charges the enemy in turn, relying on the works to cover its retreat if driven back.

In every combination of this nature the flanks are the weak points; they should rest, if practicable, on some unassailable point, as a marsh, river, &c.; otherwise very strong works should be thrown up for their protection.

41. Multiple Lines. It has been proposed, by some writers, to throw up several lines of detached works for the defence of a position; so that the troops in the first line may retreat under cover of the second, and so on. This arrangement, in the first place, can seldom be made, without *weakening the order of battle*, and therefore weakening the defence, by too great a dissemination of the troops. Moreover, in works of great extent there never can be that concert which is so essential to a vigorous defence, from the impracticability to direct it properly. The troops destined to act offensively against the enemy if repulsed, are too far in the rear to be brought up in time; and the ground being greatly cut up, by such a multiplication of works, will render the manœuvres slow and difficult. Besides, *a very capital objection in war*, the time and labor required to throw up so many works are altogether beyond what can be disposed of in the ordinary circumstances of an army.

CHAPTER IV.

GENERAL PROFILES FOR A HORIZONTAL SITE.

42. General Profile. In horizontal sites the parade may be taken either on the natural surface or below it. In enclosed works it should always be on the natural surface to keep the parade dry. In lines, particularly if of great extent and thrown up merely to receive battle or for a short occupancy, the parade may consist of a shallow trench behind the parapet which is formed of the earth taken from the trench. The general (Figs. 2 and 3) form of the parapet is the same in both cases. Its dimensions will vary with the kind of soil used in its construction; with the time and means that can be employed; with the time that the work is to remain occupied; and, finally, with the time and means that the enemy can dispose of in the attack, and the degree of resistance that the work should offer.

43. Command of Parapet. The command of the interior crest (Fig. 2) should so be regulated as to intercept the enemy's

Fig. 2

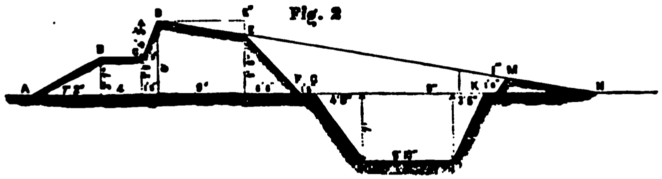


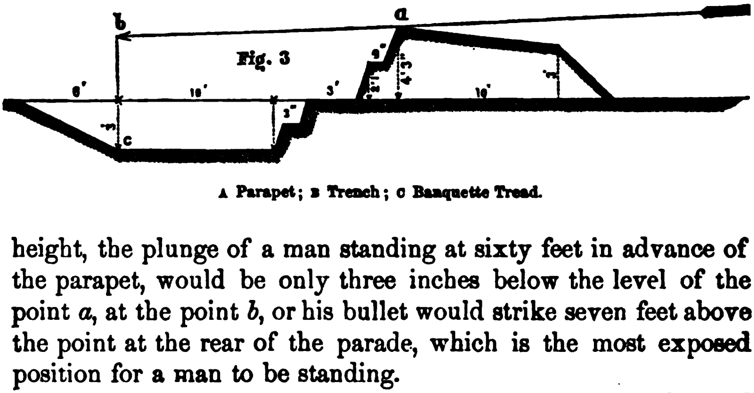
Fig. 2. This Fig. shows the ordinary form of the Profile of an Intrenchment, in soils of which the Natural Slope is one perpendicular to one base.

A B C D E F is the profile of the Parapet.
G H I K the profile of the Ditch.
L M N the profile of the Glacis.
A B is the Banquette Slope.
B C Tread of the Banquette.
C D the Interior Slope.
D E the Superior Slope.
E F the Exterior Slope.
F G the Berm.
G H the Scarp.
H I the Bottom of the Ditch.
I K the Counterscarp.

A the foot of the Banquette Slope.
B the Crest of the Banquette.
C the Foot of the Interior Slope.
D the Interior Crest.
E the Exterior Crest.
F the Foot of the Exterior Slope.
G the Crest of the Scarp.
H the Foot of the Scarp.
I the Foot of the Counterscarp.
K the Crest of the Counterscarp.
M the Crest of the Glacis.
N the Foot of the Glacis.

missiles, and to shelter the assailed. Men of the greatest ordinary stature, in bringing their muskets to an aim, do not fire at a higher level than about five feet; therefore any mass of this height in front of them will just intercept their fire; but this mass would not shelter a man standing behind it; to effect this, in the case of the tallest men usually found in the ranks, the interior crest should be at least six feet six inches above the terre-plein. The command must then be regulated by these two facts, and this principle may be laid down. *The command of a field work over the ground occupied by the assailant, should be at least five feet; and six feet six inches over that occupied by the assailed.* In following this rule for the command, we deprive the assailant of a *plunging* fire upon the parade; but as a breast height of five feet is too high for men of ordinary stature to fire over it and give their pieces any sensible depression, it would be necessary to throw up a banquette for this purpose behind the parapet, which would add to the time and labor of constructing the work. On this account it is best to give the parapet only the height to admit effective firing over it, which is about four and a quarter feet. In Fig. 3, which represents a profile of this

Fig. 3



A Parapet; B Trench; C Banquette Tread.

height, the plunge of a man standing at sixty feet in advance of the parapet, would be only three inches below the level of the point *a*, at the point *b*, or his bullet would strike seven feet above the point at the rear of the parade, which is the most exposed position for a man to be standing.

44. Normal Command. But this minimum command would give the assailed only a slight advantage, as the men, when on the banquette, would be still much exposed; and in an assault the height of the parapet would present an inconsiderable obstacle. These defects of low works have led engineers to adopt *eight feet as the least height of parapet* which will admit of a respectable defence. The *greatest height* has been fixed at *twelve feet*, owing to the difficulty of throwing up a work with the ordinary means at hand, which are usually only the pick and shovel.

45. Profile of Isolated Works. For isolated works of ordinary capacity the rule may be laid down that:

A strong profile is essential to a vigorous defence.

For the rapidity with which a column of attack approaches, and the short time it remains exposed to the fire of the work, unless detained by obstacles in front of the ditch, render its loss, generally, so trifling as not to check its march, until it arrives at the crest of the counterscarp. Here, if the ditch is deep, some delay ensues in entering it, during which the column is exposed to a warm fire within short range. When the ditch is entered, a more serious obstacle remains to be encountered, in the additional height of the parapet and scarp; and when this obstacle is overcome, the enemy presents himself in a fatigued and exhausted state to the bayonets of the assailed, who have mounted on the top of their parapet to meet and drive him back into the ditch.

46. Thickness of Parapet. The thickness of the parapet, which is always estimated by the horizontal distance between the interior and exterior crests, is regulated by the material used for the parapet; the kind of attack; and its probable duration.

The rule adopted for this is *to add to the depth of penetration of the projectile, given by experiment, one-half for this thickness.* In following this rule there will always be a thickness of earth between the extreme penetration of a projectile, at any point below the exterior crest and the interior of the work, greater than *one-third* the thickness of the parapet.

47. Superior Slope. The superior slope is arranged to defend the crest of the counterscarp; to effect which the fire should not strike below the crest, nor pass more than three feet over it; otherwise, either the counterscarp would be damaged, or the assailed by stooping when near the crest would find a shelter. The inclination of the superior slope, however, should not be *greater than one-fourth*, *nor less than one-sixth*, that is, *the base of the slope should be between four and six times the height.* If greater than one-fourth, it would make the portion of the parapet, about the interior crest, too weak; and if less than one-sixth the ground directly in front of the work would not be so well defended; moreover, as artillery cannot be fired at a greater depression than one-sixth, without injuring the carriage, this inclination of the superior slope serves as a check in rapid firing.

If, owing to the command, the fire should pass higher than three feet above the crest of the counterscarp, it would then be necessary to construct a glacis in front of the ditch. It must be so arranged that it can be swept by the fire of the work, and be commanded by it at least five feet.

48. Exterior Slope. The exterior slope *is the same that the earth naturally assumes.* Any means used to make it steeper would be injurious; because they would be soon destroyed by the enemy's fire, and the earth giving way, the necessary thickness of the parapet would be diminished.

49. Interior Slope. The interior slope *receives a base equal to one-third its height.* This is a result of experience, which has shown that it is the most convenient for the soldier in leaning forward to deliver his fire over a parapet.

50. Banquette Tread. The tread of the banquette *is placed four feet three inches below the interior crest;* this will admit men of the lowest ordinary stature, to fire conveniently over the parapet. Its width is *two feet for a defence with one rank; and four feet for two or three ranks;* because the third rank does not fire, and is therefore placed on the banquette slope, *the base of which is twice the altitude*, to render the ascent convenient. When the tread of the banquette is very high, and particularly in enclosed works, where interior space is wanted, steps may be substituted for a slope; *the rise of the step should be nine inches, and its breadth twelve inches.* The tread of the banquette should receive a slope of *two inches to the rear* to drain off the surface water.

51. Berm. The berm is a defect in field works, because it yields the enemy a foothold to breathe a moment, before attempting to ascend the exterior slope. It is useful in the construction of the work for the workmen to stand on; and it throws the weight of the parapet back from the scarp, which might be crushed out by this pressure. In firm soils, the berm may be only from *eighteen inches to two feet wide;* in other cases, as in marshy soils, it may require *a width of six feet.* In all cases, it should be *six feet below the exterior crest*—to prevent the enemy, should he form on it, from firing on the troops on the banquette.

52. Dimensions of Ditch. The ditch should be regulated to furnish the earth for the parapet. To determine its dimensions, the following points require attention: its depth should not be *less than six feet*, nor its width *less than twelve feet*, to present a respectable obstacle to the enemy. It cannot, with convenience, be made *deeper than twelve feet;* and its greatest width is regulated by the inclination of the superior slope, which, produced, should not pass *below the crest of the counterscarp.*

53. Scarp and Counterscarp. The slopes of the scarp and counterscarp will depend on the nature of the soil, and the action on it of frost and rain. The scarp is less steep than the counterscarp; because it has to sustain the weight of the parapet. It is usual to give the slope of the scarp, a base equal to *two-thirds* of the base of the natural slope of a mound of fresh earth whose altitude is equal to the depth of the ditch; the base of the counterscarp slope is made equal to *one-half* the same base.

To determine the exact dimensions of the ditch, for a given parapet, requires a mathematical calculation, which is given in Note B. On the field a result may be obtained, approximating sufficiently near the truth for practice, by assuming the depth of the ditch and dividing the surface of the profile of the parapet by it to obtain the width. In excavating the ditch it will be found that more earth will be furnished at the salients than is required there for the parapet; and that the reënterings will not always furnish enough. On this account, the width of the ditch should not be uniform, but narrower at the salients than the reënterings.

54. Height of Salients. The salients of the parapet on horizontal sites, are sometimes made higher than the reënterings, a gradual slope being given to the interior crest from the salients to the reënterings, with a view to cover better the terre-plein, towards these last points, from the plunge of an enfilading fire on the faces. The effect of this, however, is but trifling, as the descending plunge of the projectile is the greater, as the salient is higher over which it passes. On such sites, therefore, the profile of the parapet is usually uniform throughout.

CHAPTER V.

MANNER OF PROFILING, TRACING, AND THROWING UP A WORK.

THE foregoing chapters contain all that is requisite to determine the plan and relief of field works. To follow a natural order, the next steps will be to describe the manner of setting out the outline of the plan, or *tracing* the lines on the ground; setting up skeleton frames, termed *profiling*, of the outline of the parapet; and of distributing the working parties to excavate the ditch, form the parapet, level and drain the parade, etc.

55. Profiling and Tracing. Poles (Fig. 20) having been planted at the angles of the work, and the height of the interior crest marked on them, a line is traced on the ground with a pick, showing the direction of the interior crests. When the ground is sensibly level, lines perpendicular to the direction of the interior crest are traced upon it, at suitable distances, from twenty to thirty yards apart, to mark the positions of the profiles, and the horizontal distances for the thickness of the parapet; the bases of the slopes, etc., are set off on these lines. But when the ground along the direction of the profile is undulating, or slopes in either direction, cords are stretched above the surface, in a horizontal line, between two stout pickets, in the direction of the profiles, and so as to include all of its lines. This cord serves to measure the horizontal distances on, and to find the points of the profile, above and below it, by means of an ordinary plummet. A stout square picket is driven firmly into

Fig. 20.

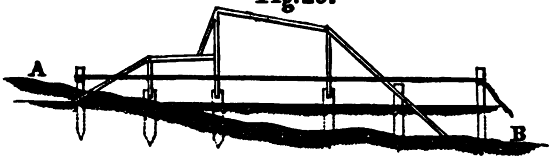


Fig. 20. Profile of Slats. A B Inclined Ground.

the ground, where the cord crosses above the pick-line, and a slip of pine, on which the height of the interior crest is marked, is nailed to the picket. The thickness of the parapet is measured on the cord, and a picket driven into the ground to mark the point. The base of the interior slope, and the tread of the banquette, are set off in a similar manner; and a slip of deal is nailed to each of the pickets. The height of the interior crest, and the tread of the banquette, are easily ascertained, from the position of the cord and the interior crest; these points having been marked on their respective slips, the outline of the parapet is shown by connecting them by other slips, which are nailed to the uprights; the banquette slope and exterior slope will be determined by a similar process.

From the profiles thus formed perpendicular to the interior crests, the oblique profiles at the angles can readily be set up, by a process which will suggest itself without explanation.

Having completed the profiling, the foot of the banquette, and that of the exterior slope, are marked out with the pick, and also the crests of the scarp and counterscarp. All the arrangements preparatory to commencing the excavation are now complete.

56. Distribution of Working Parties. Experience has shown that, in ordinary soils, a man with a pick can furnish employment to two men with shovels; that, not to be in each other's way, the men should be from four-and-a-half to six feet apart; and, finally, that a shovelful of earth can be pitched by a man twelve feet in a horizontal direction, or six feet in a vertical direction.

To distribute the workmen, the counterscarp crest is divided off into lengths of twelve feet, and the interior crest into lengths of nine feet. These points might be marked out by pickets numbered one, two, three, etc. In each area, thus marked out, a working party is arranged consisting of a pick with two shovels placed near the counterscarp, two shovels near the scarp, and one man to spread, and one to ram the earth, for two working parties.

57. Construction of Parapet, etc. The pick commences by breaking ground so far from the counterscarp crest (Fig. 21) that, by digging vertically three feet, he will arrive at the position of the counterscarp. The excavation is carried on at the same depth of three feet, advancing towards the scarp, where the same precaution is observed as at the counterscarp. The earth is thrown forward, and evenly spread and rammed, in layers of about twelve inches, from the banquette slope to the exterior slope.

Fig. 21.

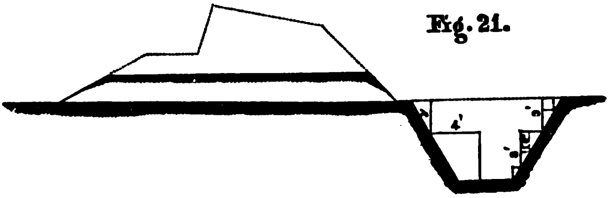


Fig. 21. Shows profile of work in process of execution.

For the facility of entering the ditch, whilst working, the offsets at the scarp and counterscarp may be formed into steps with a rise of eighteen inches each; and, if the ditch is deeper than six feet, an offset, about four feet broad, should be left at the scarp, about mid-depth of the ditch, to place a relay of shovels to throw the earth on the berm. In some cases, a scaffold of plank is raised in the ditch for the same purpose.

When the ditch has been excavated to the bottom, the offsets are cut away, and the proper slopes given to the sides. The earth furnished by the offsets, if not required to complete the parapet, may be formed into a small glacis.

If the soil is stony, the vegetable mould on the surface should be scraped off, and reserved to form the top of the parapet, which should be made of earth of this kind, to the depth of at least eighteen inches, to prevent injury to the troops from the effect of a shot striking the top, and scattering the pebbles in their faces.

In making the parapet, care should be taken to form a drain, at some suitable point, to carry off the water from the interior into the ditch. The water from the drain should not be suffered to run down the scarp, as it would soon destroy it. A gutter, formed of boards, should be made to prevent this.

58. **Tasking.** The time required to throw up a work will depend on the nature of the soil and the expertness of the laborers. From troops unaccustomed to the use of ditching tools, six cubic yards may be considered a fair day's work in ordinary

soils, when the earth is not thrown higher than six feet; but when a relay is placed on an offset in the ditch, from four to five cubic yards may be taken as the result of a day's work for each man. Expert workmen will throw up from eight to ten cubic yards at task work.

CHAPTER VI.

REVETMENTS.

59. Revetments. A *revetment* consists of a facing of stone, wood, sods, or any other material, to sustain an embankment, when it receives a slope steeper than the natural slope.

In field works revetments are used only for the interior slope of the parapet and for the scarp; for the first, sods, pisa, fascines, hurdles, gabions, and plank, are chiefly used; and for the last, timber.

60. Revetment of Sods. Sod work forms a strong and durable revetment. The sods should be cut from a well-clothed sward, with the grass of a fine short blade, and thickly matted roots. If the grass is long, it should be mowed before the sod is cut.

Sods are of two sizes (Fig. 22); one termed *stretchers*, are twelve inches square, and four-and-a-half inches thick; the others, termed *headers*, are eighteen inches long, twelve inches broad, and four-and-a-half inches thick.

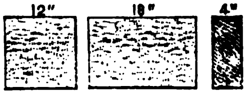


Fig. 22. Plan and Section of Sods.

The sod revetment (Fig. 23) is commenced as soon as the parapet is raised to the level of the tread of the banquette. A course of sods is then laid, either horizontal or a little inclined from the banquette; the course consists of two stretchers and one header alternating, the end of the header laid to the front. The grass side is laid downward to facilitate the trimming of the top surface to a level or plane; and the sods should protrude a little beyond the line of the interior slope, for the purpose of trimming the course even at top, before laying another, and to make the interior slope regular. The course is firmly settled, by tapping each sod as it is laid with a spade or a wooden mallet; and the earth of the parapet is packed closely behind the course.

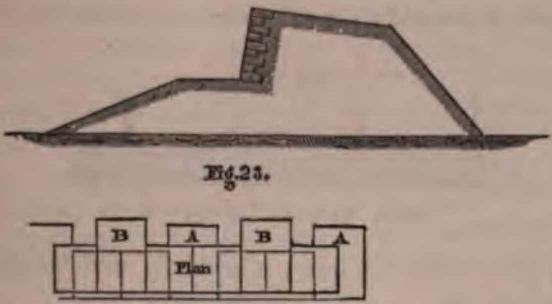


Fig. 23. Profile and Plan of Sod work.
A Headers. B Stretchers.

A second course is laid on the first, so as to cover the joints, or, as it is termed, to *break joints* with it; using otherwise the same precautions as with the first. The top course is laid with the grass up; and in some cases pegs are driven through the sods of two courses to connect the whole more firmly, which is, however, by no means necessary to form a strong sodding.

When cut from a wet soil, the sods should not be laid until they are partially dried, otherwise they will shrink, and the revetment will crack in drying. In hot weather the revetment should be watered frequently, until the grass puts forth. The sods are cut rather larger than required for use, and are trimmed to a proper size from a model sod.

61. Pisa Revetment. Ordinary earth, if mixed with a proper proportion of clay, and the whole well kneaded with just water enough to cause the particles to adhere when squeezed in the hand, may be used for a revetment, and is termed a pisa revetment. Sometimes chopped straw is mixed up with the mass to cause it to bind better.

The pisa is laid in layers of twelve inches thick, and two feet broad, and well packed. The same precautions should be taken in forming the parapet behind it as in sod revetments. The face of the revetment may be sown with grass-seed or oats, and when the stalk comes to maturity it should not be cut, but suffered to remain as a kind of thatch to protect the facing from the weather.

62. Fascine Revetment. A *fascine* (Fig. 24) is a bundle of twigs closely bound up. There are two sizes of fascines; one size is nine inches in diameter, and about ten feet long; the other, which is generally termed a *saucisson*, is twelve inches in diameter and twenty feet long; it is chiefly used for the revetments of batteries.

Fig. 24.

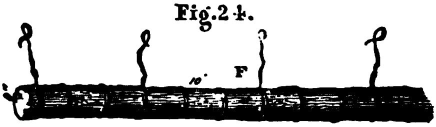


Fig. 24. Fascine and Anchoring Gads.

To make a fascine, straight twigs are selected, between the thickness of the little finger and thumb, the longer the better; they should be stripped of the smaller twigs. A support, termed a *fascine horse* (Fig. 25), is put up, by driving two stout poles obliquely into the ground about two feet, so as to cross each other about two feet above the ground, where they are firmly tied together; as many of these supports as may be required are put up in a straight line, about eighteen inches apart; this forms the horse on which the twigs are laid to be bound together.

Fig. 25.

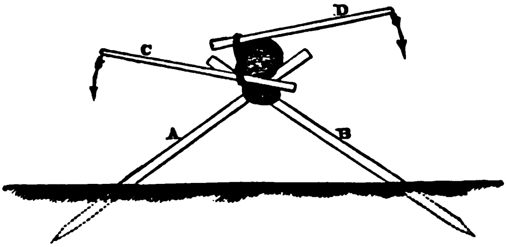


Fig. 25. A and B Legs of Horse; C and D Levers.

A machine, termed a *fascine choker*, is formed of two stout levers about five feet long, connected near their extremities by a chain or strong cord, which should be long enough to pass once round the fascine, and be drawn tight by means of the levers.

The twigs are laid on the horse, with their large and small ends alternating; the choker is applied to bring them together; and they are bound by *withes*, or *gads*, made of tough twigs, properly prepared by untwisting the fibres over a blaze, so as to render them pliant; or else stout rope yarn or wire may be substituted for them. The gads are placed twelve inches apart, and every third or fourth one should be made with an end about three or four feet long, having a loop at the extremity to receive a picket through it; this picket is termed an *anchoring picket*, its object being to secure the fascine firmly to the parapet.

To form the revetment, the first row of fascines (Fig. 26) is imbedded about half its thickness below the tread of the banquette, and is secured by means of the anchoring pickets, and also by several pickets driven through the fascine itself about twelve inches into the earth. The knots of the withes are laid inside, and the earth of the parapet is well packed behind the fascine. A second row is laid on the first, so as to give the requisite interior slope; it should break joints with the first row, and be connected with it by several pickets driven through them both. The other rows are laid with similar precautions; and the parapet is usually finished at top by a course of sods.

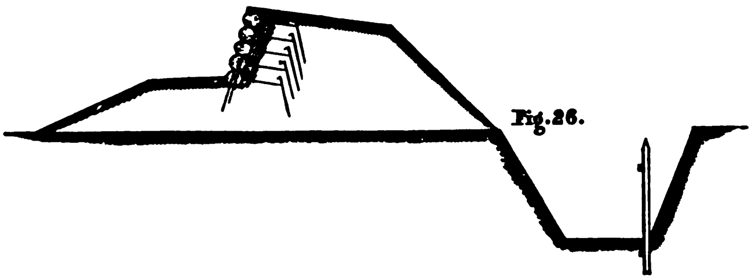


Fig. 26. Profile of Fascine work and a Palisaded ditch.

63. Hurdle Revetment. This revetment is made by driving poles (Fig. 27) in the same direction as the interior slope, into the banquette, about eighteen inches below the tread, and then forming a wicker-work, by interlacing twigs between them in a similar manner to basket work.

The poles should be nine inches apart, their diameter about one-and-a-half inches. They should be secured to the parapet by long withes and anchoring pickets. The top twigs should be bound together by withes.

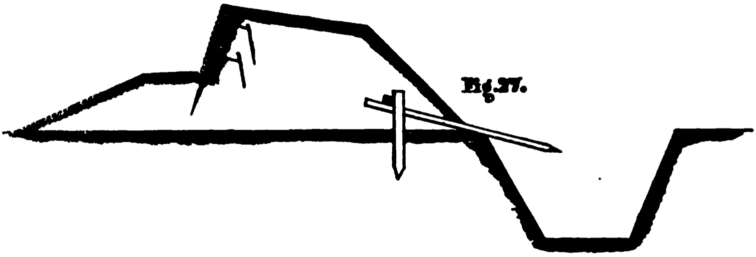


Fig. 27. Hurdle Revetment and Fraise.

64. Gabion Revetment. The *gabion* (Fig. 28) is a round basket of a cylindrical form, open at each end; its height is usually two feet nine inches, and diameter two feet.

To form a gabion, a *directing circle* is made of two hoops, the difference between their radii being such, that, when placed concentrically, there shall be about one-and-three-quarter inches between them. They are kept in this position by placing small blocks of wood between them, to which they are tied with packthread. The directing circle is laid on the ground, and seven or nine pickets, about one inch in diameter and three feet long, are driven into the ground between the hoops, at equal distances apart; the directing circle is then slipped up midway from the bottom, and confined in that position. Twigs half an inch in diameter, and as long as they can be procured, are wattled

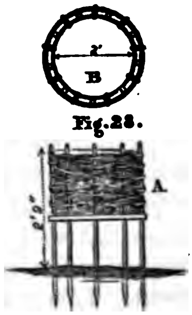


Fig. 28. A Elevation of Gabion half finished; B plan of Directing Hoops.

between the pickets, like ordinary basket work; when finished within about one-and-a-half inches of the top, the gabion is placed with the other end up, the directing circle is taken off, and the gabion is completed within the same distance from the other extremities of the pickets. The wicker work at the two ends is secured by several withes, and the ends of the pickets being brought to a point, the gabion is ready for use.

The gabion revetment is seldom used except for the trenches in the attack of permanent works, where it is desirable to place troops speedily under cover from the enemy's case-shot and musketry. When used for field works (Fig. 29), a fascine is first laid partly imbedded below the tread of the banquette; the gabion, which is placed on end, rests on this, so as to give it the requisite slope; it is filled with earth, and the parapet is raised behind it, and another fascine is laid on top, and in some cases two.

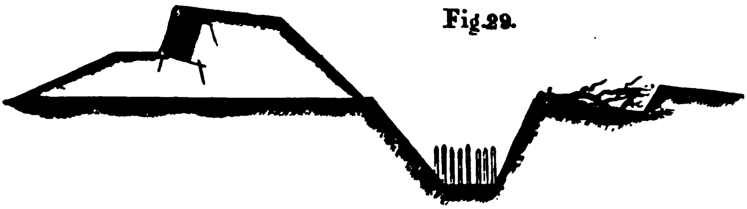


Fig.29.

Fig. 29. Profile of Gabion and Fascine work; Small Pickets in ditch, and an Abattis behind a Glacis.

65. Plank Revetment. This revetment may be made by driving pieces of four-inch scantling about three feet apart, two feet below the tread of the banquette, giving them the same slope as the interior slope. Behind these pieces, boards are nailed to sustain the earth.

66. Sand bags are sometimes used for revetments when other materials cannot be procured; though their object, in most cases, is generally to form a speedy cover for a body of men. They are usually made of coarse canvas; the bag, when empty, is two feet eight inches long, and one foot two inches wide; they are three-fourths filled with earth, and the top is loosely tied. They are laid like sod work, and with the same care in packing and levelling. From their perishable nature, they are only used for a temporary purpose, as when troops are disembarked on an enemy's coast.

67. Scarp Revetment. This revetment (Fig. 30) is formed

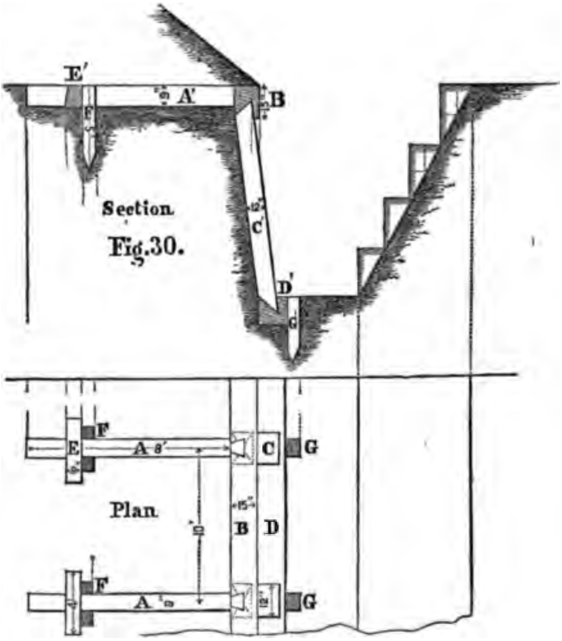


Fig. 30. Shows a plan and section of a timber revetment. B B', is the cap; D, D', the sill; C, C', uprights let into B and D; A, A', the land-ties, dove-tailed into B, and confined by the cross-pieces E, E', halved into them, and by the square short piles F; G G' are the piles to retain the sill.

of a framework of heavy timber, and is used only for important field forts. A piece, termed a *cap*, or *cap-sill*, is imbedded in a trench made along the line of the berm; other pieces, termed *land-ties*, are placed in trenches perpendicular to the cap, with which they are connected by a dove-tail joint; they are about eight or ten feet asunder. Cross pieces are halved into the land-ties about two feet from their extremities, and two square piles, about five feet long, are driven in the angles between the land-ties and cross pieces; inclined pieces, which serve as supports to the cap, are mortised into its under side at the same points as the land-ties. These supports usually receive a slope of ten perpendicular to one base; they generally rest on a *ground-sill* at the bottom of the ditch, to which they are mortised; this sill being held firm by square piles. The ground-sill may be omitted, by driving the supports below the bottom of the ditch.

Behind this framework, thick plank, or heavy scantling, is placed side by side, having the same slope as the supports; or else a rabate may be made in the cap and ground-sills, and the scantling be let in between these two pieces, serving as a support to the cap. This is the more difficult construction, but it is the better, since, should the heavy supports be cut away, the cap will still be retained in its place.

Scarp revetments are sometimes formed by laying heavy timber in a horizontal position; but this method is bad, as it enables the enemy to gain a foothold by thrusting their bayonets between the joints.

The length of the land-ties should be at least equal to two-thirds the depth of the ditch.

The counterscarp is seldom reveted. A framework similar to that for the scarp might be used, and thick boards, laid horizontally, be substituted for the inclined scantling.

When a scarp revetment is made, the excavation of the ditch must be conducted in a different manner from that already explained. In this case, after the cap-sill and land-ties are laid, the excavation is continued to the bottom of the ditch, by removing only earth enough to allow the framework to be put up. A scaffolding of plank is then raised in the ditch on which the earth, that remains to be excavated, is thrown, and from there on the berm.

CHAPTER VII.

INTERIOR ARRANGEMENTS.

68. Classification. Under the head of interior arrangements is comprised all the means resorted to within the work to procure an efficient defence; to preserve the troops and the *material* from the destructive effects of the enemy's fire; and to prevent a surprise.

The class of constructions required for the above purposes, are *batteries; powder-magazines; traverses; bomb and splinter-proof shelters; enclosures for gorges*, and *outlets; interior safety-redoubt*, or *keep;* and *bridges of communication.*

69. Musketry Armament. All arrangements made for the defence, with musketry and artillery, belong to what is termed the *armament.*

The armament with musketry is complete when the banquette and the interior and superior slopes are properly arranged, to enable the soldier to deliver his fire with effect; and to mount on the parapet to meet the enemy with the bayonet. For this last purpose stout pickets may be driven into the interior slope, about midway from the bottom, and three feet apart, or a narrow plank may be laid along this slope. The armament with artillery is, in like manner, complete, when suitable means are taken to allow the guns to fire over the parapet, or through openings made in it; and when all the required accessories are provided for the service of the guns.

70. Artillery Armament. The armament with artillery is a subject of great importance, because it is not equally adapted to all classes of works. Experience has demonstrated that the most efficient way of employing artillery, is in protecting the collateral salients by a well directed flank and cross-fire, which shall not leave untouched a single foot of ground within its range, over which the enemy must approach. It has moreover shown, that a work with a weak profile affords but little security to artillery within it; for artillery cannot defend itself, and such a work can be too easily carried by assault to offer any hope of keeping the enemy at a distance long enough to allow the artillery to produce its full effect.

The proper positions for artillery are on the flanks and salients of a work; because from these points the salients are best protected, and the approaches best swept; and the guns should be collected at these points in batteries of several pieces; for experience has shown that it is only by opening a heavy, well-sustained fire on the enemy's columns, that an efficient check can be given to them. If only a few files are taken off, or the shot passes over the men, it rather inspires the enemy with confidence in his safety, and with contempt for the defences.

71. Batteries. The term battery is usually applied to a collection of several guns; it is also used in speaking of the arrangements made of a parapet to enable the guns to fire over it, or through openings in it; as a *barbette battery*, an *embrasure battery*, etc. Two kinds of batteries are used in the defence of intrenchments, the barbette battery and the embrasure battery.

72. Barbettes. The barbette is a construction by means of which a piece can fire over a parapet. It consists of a mound of earth, thrown up against the interior slope; the upper surface of which is level, and two feet nine inches below the interior crest for guns of small calibre, and four feet for heavy guns. If the barbette is raised behind a face, its length should be sufficient to allow sixteen and a half to eighteen feet along the interior crest for each gun; and its *depth*, or the perpendicular distance from the foot of the interior slope to the rear, should be twenty-four feet, for the service of the guns. The earth of the barbette at the rear and sides receives the natural slope. To ascend the barbette, a construction termed a *ramp* is made; this is an inclined plane of earth, which connects the top of the barbette with the terre-plein. The ramp is ten feet wide at top, and its slope is six base to one perpendicular. The earth at the sides receives the natural slope. The ramp should be at some convenient point in the rear, and take up as little room as possible.

As barbettes are usually placed in the salients, an arrangement is made for the guns to fire in the direction of the capital. The construction in this case is somewhat different from the preceding. A pan-coupée D of eleven feet (Fig. 31) is first made;

from the foot of the interior slope at the pan-coupée, a distance of twenty-four feet is set off along the capital; at the extremity of this line a perpendicular is drawn to the capital; and

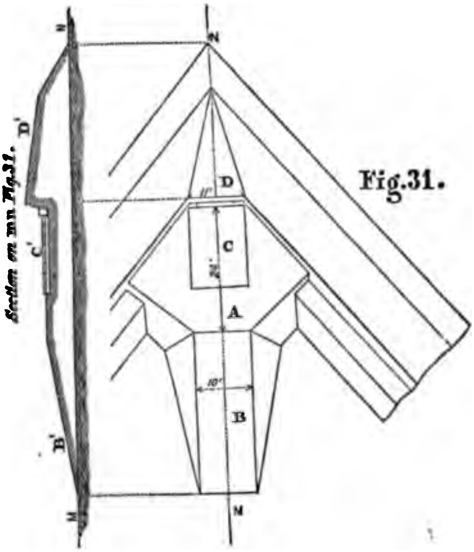


Fig.31.

five feet are set off on this perpendicular on each side of the capital; from each of these points, on the perpendicular, a line is drawn perpendicular to each face respectively; the hexagonal figure, C, thus laid out, is the surface of the barbette for one gun. The ramp B in this case is made along the capital.

If three or more guns are placed in the salient, a pan-coupée is formed as in the last case; and twenty-four feet (Fig. 32) are in like manner set off on the capital; but instead of proceeding as in the last case, a perpendicular is drawn from this point to each face, and the pentagonal space, thus enclosed, will be taken for the gun in the salient; from the perpendiculars last set off, as many times sixteen and a half feet will be set off, on the interior crest of each face, as there are guns required: this will give the length of the barbette along each face; the depth will be made twenty-four feet, and the two will be united in the salient. One or more ramps may be made as most convenient.

To give temporary cover to guns on a field of battle and enable them to command a wide field of fire, a parapet of just sufficient height to allow the guns to fire over it, may be thrown up for the purpose, the earth being taken from a ditch in front. The ground may be roughly levelled off far enough to the rear

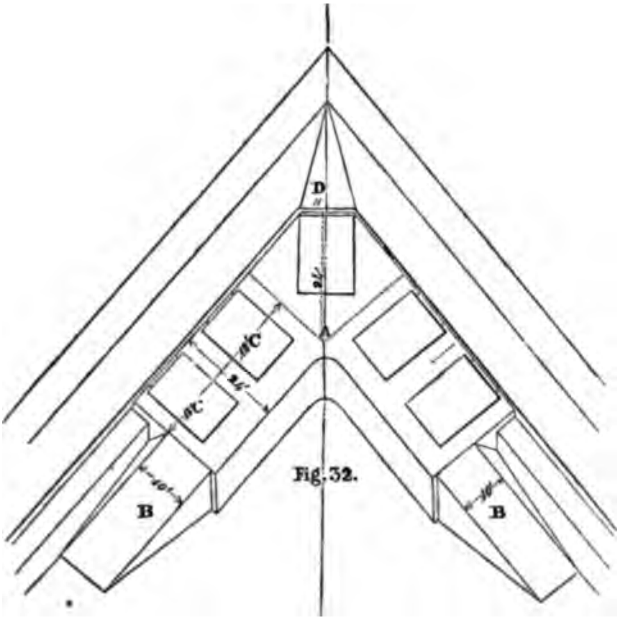


Fig. 32.

for the manœuvre of the guns. Between each gun a shallow trench may be dug parallel to the wheels, where the gunners can find shelter when not serving their pieces.

The advantages of the barbette consist in the commanding position given to the guns, and in a very wide field of fire; on these accounts the salients are the best positions for them. Their defects are, that they expose the guns and men to the enemy's artillery and sharpshooters.

Light guns, particularly howitzers, are the best for arming barbettes; because the hollow projectile of the latter is very formidable, both to the enemy's columns and to his cavalry; and when his batteries are opened against the salients, the light pieces can be readily withdrawn.

73. Embrasures. The embrasure (Fig. 33) is an opening made in the parapet for a gun to fire through. The bottom of the embrasure, termed the *sole*, is two feet nine inches, or four feet above the ground, on which the wheels of the carriage rest, according to the size of the gun; it slopes outwards to allow the

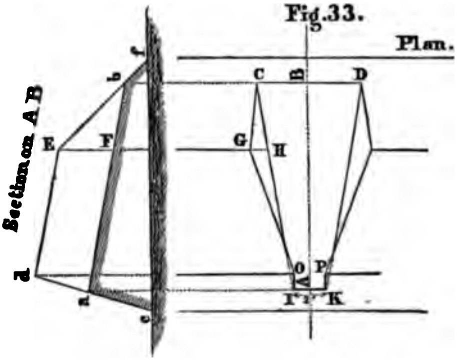


Fig. 33. I K, width of Sole at the mouth; C D—½ A B, width on exterior; G H—½ E F; a b inclination of Sole; a d E b, elevation of cheek.

gun to be fired under an inclination; the base of this slope should never be less than six times the altitude; the interior opening, termed the *mouth*, is from eighteen inches to two feet wide, according to the calibre of the gun, and is of a rectangular, or trapezoidal form; the embrasure widens towards the exterior, which widening is termed the *splay;* the manner in which the splay is usually regulated, is by producing the sole to the exterior slope of the parapet, and making this exterior line, measured on the sole, equal to half the distance between the inner and outer lines of the sole. This construction makes the sole a trapezoidal figure; the side of the trapezoid, on the interior being eighteen inches, or two feet; the opposite side being equal to half the perpendicular distance between the two sides. The rule here given for the splay is not absolute. It will in all cases be adapted to the field of fire required for the defence. The line which bisects the sole is termed the *directrix* of the embrasure; the sides of the embrasure, termed the *cheeks*, are laid out, by setting off two points on the exterior crest of the parapet, one on the right, the other on the left of the sole, so that the horizontal distance of these points from the sole shall be equal to one-third their height above it. Lines are then drawn, on the exterior slope, from these points to the exterior points of the sole; lines are in like manner drawn from the same points, on the superior slope, to the upper points of the mouth, on the interior crest. These four lines form the boundaries of the two cheeks on the superior and exterior slopes.

When the directrix is perpendicular to the direction of the parapet, the embrasure is termed *direct;* when the directrix makes an acute angle with it, the embrasure is termed *oblique.*

The manner of laying out an oblique embrasure (Fig. 34) is similar to the direct; the mouth is of a rectangular form, but is made wider in proportion to the obliquity, in order that the part of the embrasure which corresponds to the muzzle of the gun may be nearly of the same width in both the direct and oblique embrasures. The exterior width of the sole is made equal to one-half the length of the directrix, measured on the sole. The cheeks are laid out as in the last case.

The muzzle of a gun should enter at least six inches into the embrasure, to prevent the blast from injuring the cheeks; this limits the obliquity of the directrix to about 60 for long guns.

The height of the cheeks must not be more than four feet for the same reason; it will, therefore, in most cases, be necessary to raise the ground on which the wheels rest, giving to the top surface the same dimensions as for a barbette, and forming the side slopes and ramps in like manner.

The parapet of a battery is usually termed the *epaulment.* This term is more properly applied to the two returns or wings of the flanks of a battery which cover the guns and men from a slant fire on the flanks. The interior face of the epaulment, and the cheeks of the embrasures, are reveted in the usual manner. The part of the interior face which lies below the chase of the gun is termed the *genouillère.* The mass of earth between two embrasures is termed a *merlon.*

The embrasures are generally cut out after the epaulment is thrown up. If their position is decided upon beforehand, they may be roughly formed at first, and be finished after the epaulment is made.

The advantages of embrasures are, that the men and guns are less exposed than in a barbette battery. Their principal defects are, that they have a very limited field of fire; they weaken the parapet, and present openings through which the enemy may penetrate in an assault. Owing to their limited field of fire, they are chiefly used for the protection of particular points; as to flank a ditch, protect a salient, enfilade a road, etc. The most suitable position for them in a work is on the flanks.

74. Platforms. When a gun is fired often in the same direction, the ground under the wheels is soon worn into ruts; it is to prevent this that platforms of timber are used in such cases.

The shape of the platform is usually a rectangle; in some cases, where a wide field of fire is to be obtained, the form is a trapezoid. The rectangular platform (Fig. 34) is ten feet wide and seventeen feet long, for siege pieces; and nine feet wide and fifteen long, for field guns. It consists of three *sleepers* of six-inch scantling, either fifteen or seventeen feet long, which are laid perpendicular to the direction of the epaulment, and are covered with two-inch plank, twelve inches wide, and cut into lengths of nine or ten feet. Between the ends of the sleepers and the foot of the genouillère, a piece of eight-inch scantling, nine feet long, termed a *heurter*, is laid; it should project about six inches above the platform, and be bisected by the directrix. The object of the heurter is to prevent the wheels from being run against the revetment, and also to give the gun its proper direction, particularly in night firing.

Fig. 34.

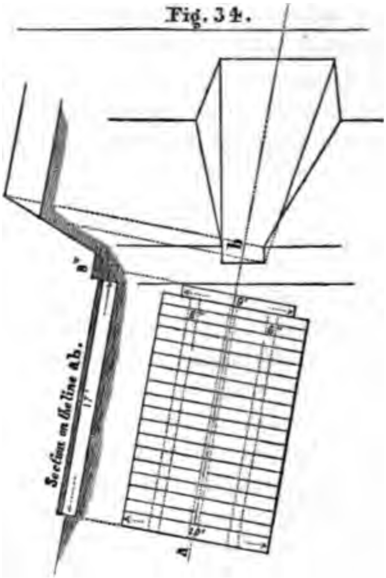


Fig. 34. Plan and Section of Oblique Embrasure and Platform.

To lay a platform, the earth on which it is to rest should be well rammed and levelled; three trenches are then made for the sleepers, two of which should be placed under the wheels, and the middle one under the trail. The sleepers are laid flush with the ground, and firmly secured by pickets driven at their sides and ends, and the earth is solidly packed in the trench around them; the plank is then laid and secured by nails, or some other fastenings.

If the platform is for direct firing, with full charges, the *tail* may be made six inches higher than the front to break the recoil; in all other cases it should be horizontal.

A platform may be constructed simply of three pieces of timber (Fig. 35), one under each wheel, and one under the trail, firmly secured by pickets, and connected by cross pieces, into which they are halved.

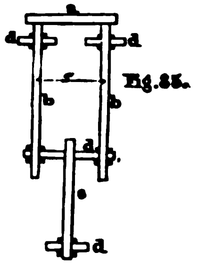


Fig. 35. a Heurter, b Rails, c Tail Rail, d; Cross Ties.

For barbettes, the platform may be dispensed with, or, if used, the whole surface nearly of the barbette should be covered.

If the platform is made of a trapezoidal form, it will require five sleepers.

75. Powder Magazines. The main objects to be attended to in a powder magazine are, to place it in the position least exposed to the enemy's fire; to make it shot-proof; and to secure the powder from moisture.

If there are traverses, such, for example, as are used in defilement, the magazines may be made in them; or they may be placed at the foot of a barbette; or, in dry soils, be made partly or wholly under ground.

The magazine should be at least six feet high, and about the same width within; its length will depend on the quantity of ammunition. It may be constructed of fascines, gabions, or *coffer-work*, or any means found at hand may be used which will effect the end in view.

76. If fascines are used, the sides (Fig. 36) should slope outwards to resist the pressure of the earth; the fascines should be firmly secured by pickets and anchoring withes. The top may be formed by a row of joists, of six-inch scantling, placed about two and a half feet apart; these should be covered by two layers of fascines laid side by side, and the whole be covered in by at least three feet thickness of earth. The bottom should be covered by a flooring of joists and boards; a shallow ditch being left under the flooring, with a pitch towards the door of the magazine, to allow any water that might leak through to be taken out. A thatch of straw might be used on the inside, but it is somewhat dangerous, owing to its combustibility; hides or tarpaulins are better, and will keep out the moisture more effectually.

Fig.36.

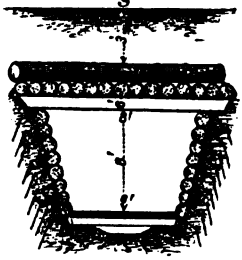


Fig. 36. Cross Section of Magazine.

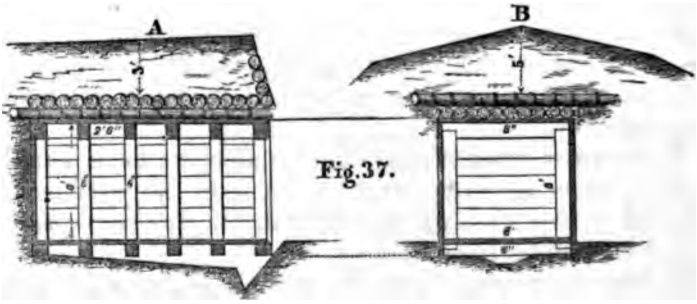


Fig.37.

Fig. 37. A Longitudinal Section of Coffer Magazine; B Cross Section.

77. A *coffer-work* is formed by making frames (Fig. 37) of six-

inch scantling; each frame is composed of two uprights, termed *stanchions*, and a cap and ground-sill, well nailed together; it is six feet wide, and six feet high in the clear. These frames are placed upright, and parallel to each other, about two and a half feet apart; they are covered on the top and sides by one and a half inch plank, which is termed a *sheeting*. The magazine otherwise is constructed as in the last case.

78. When gabions are used, a hole is usually dug in the ground to form a part of the magazine; the gabions (Fig. 38) are placed in two rows, side by side, around the hole, and are filled with earth. The top is formed as in the case of fascines.

Fig.38.

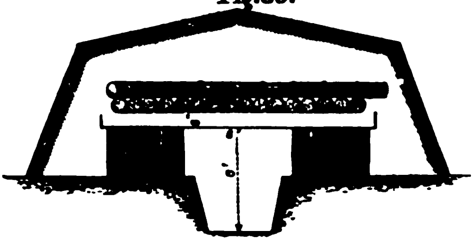


Fig. 38. Shows the cross section of a Gabion Magazine.

79. Splinter Proof. The mouth of the magazine is covered by a *splinter proof shelter*. This is constructed (Fig. 39) by taking scantling eight by ten inches, cut into suitable lengths, and placing it in an inclined position, so as to cover the mouth, and leave an easy access to it. The pieces usually are inclined

Fig.39.

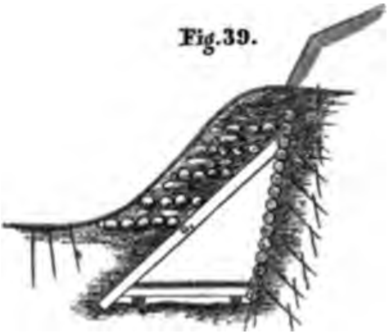


Fig. 3. Shows a cross section of a Splinter Proof Shelter laid against the side of a Traverse. The traverse is revetted with fascines, and the timber work is covered with sandbags and tarpaulins, or raw hides.

45°, and are placed side by side; they are covered by at least two feet of earth, or sods; and hides or tarpaulins are thrown over the whole.

The magazines here described, are only suited for works which are not expected to be occupied but for some weeks and are not exposed to an attack of any but light field guns. In all cases where lumber is abundant, it will be best to cover at top by a foot in thickness of pieces laid in juxtaposition, and to give a covering of at least six feet thickness of earth on the most exposed side, and place the magazine entirely underground.

Splinter proofs (Fig. 39, bis) for trenches and enclosed works faced with timber from eight to twelve inches diameter, and covered with a sheeting of thick boards, and from four to six feet of earth, which are supported by uprights at the back; having a board flooring as shown in the figure, have been recently used in our field works and trenches with great benefit in the saving of life.

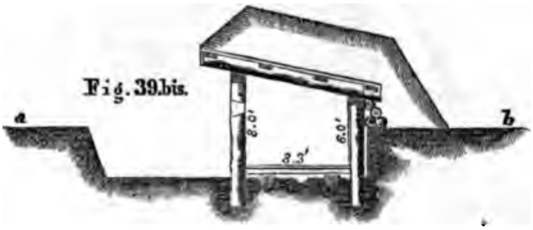


Fig. 39, bis. Shows a section of a Splinter Proof used in the trenches at the Siege of Fort Wagner.

80. Bomb Proof Magazines. For field works of a semi-permanent character which are to be indefinitely occupied, have an armament of heavy guns, and are expected to stand a siege, like the defences around Washington for example. The magazines, bomb, and splinter proof shelters, should be constructed of the heaviest timber, and be covered securely with earth from the assailant's curvated and direct fire.

The ventilation of the magazines and precautions for their drainage, are of the utmost importance. Figs. 40 and 41 give the plan and a cross-section of a magazine constructed in a work of this character. The sides of the interior of the magazine are formed of twelve-inch logs placed vertically in juxtaposition and resting upon a ground-sill. These are capped on top by a

Fig. 40.

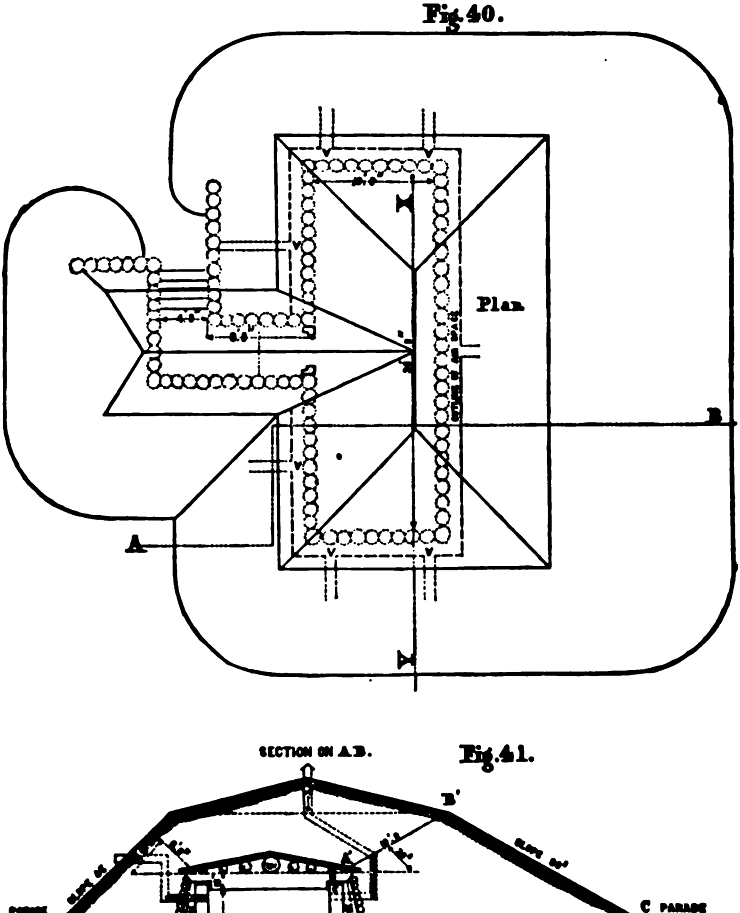


Fig. 41.

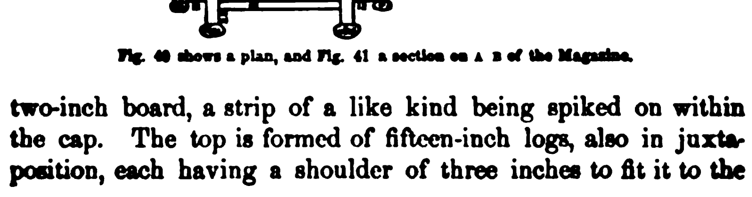


Fig. 40 shows a plan, and Fig. 41 a section on A B of the Magazine.

two-inch board, a strip of a like kind being spiked on within the cap. The top is formed of fifteen-inch logs, also in juxtaposition, each having a shoulder of three inches to fit it to the cap and inside strip. Longitudinal logs are laid on these with varying diameters, so as to give a proper pitch for the roof. Earth is solidly packed upon the top and between the roof logs, receiving the proper slope for the roofing boards. These boards, carefully jointed, are laid on in two thicknesses, each being covered with a coating of asphalte. The flooring of the magazine is of joists and boards.

The sides of the magazine are surrounded with an air-chamber formed by inclined logs supported on a ground-sill and resting against the top logs; these are placed at three or four feet apart, each one being braced at the middle point to resist flexure from the pressure of earth. The chamber is covered in by saplings laid in juxtaposition. There are ventilators between the magazine and the air-chamber near the top, and also between the latter and the external air; the two not being opposite, and the usual precautions to guard against accidents from sparks being taken. The earth-cover is ten feet on the exposed side, and six feet on the other sides and on top.

The entrance to the magazine is well secured by a bomb proof covering. A slope is given from the interior to the foot of the steps leading to the level of the floor for the purposes of draining.

81. Bomb Proof Shelters. Bomb and splinter proof shelters of wood have also been carefully built in the interior of some of these enclosed works, and in the gorges of those open to the rear; both may be arranged with loop-holes for defence. These are mostly constructed in the manner shown in Fig. 39, bis. The exterior side is of heavy logs placed in juxtaposition, resting on a ground-sill and capped at top. Parallel to these is another row, which may also be in juxtaposition or at short intervals apart and capped like the outside row. The roofing, consisting of heavy logs laid in juxtaposition and covered by thick jointed boards, rests on the capping. The back face may be sealed on the inside to obviate the dampness from the earth resting against the back; and some simple method of drainage, by fascines or tiles, is arranged to carry off the water from the earthen covering. This last should be the same as for the powder magazines.

It is highly important that these works should be so organized as to afford a retreat for the garrison should the main work be carried. This might be done in some cases, by masking, with earth, only the lower portion of the side looking on the interior of the work, and covering the exposed timber with iron plating with loop-holes, to sweep all the interior space.

82. **Traverses.** Those which are constructed to cover the flanks of the guns from an enfilade fire, are usually what are termed *gabionades*. To form a gabionade, gabions are placed in a row (Fig. 42), side by side, enclosing a rectangular space of about twelve feet in width from out to out, and about twenty-four feet in length, perpendicular to the epaulment. A second row is placed within this and touching it. The area thus enclosed is filled in with earth, to a level with the top of the gabions. Four rows of large fascines are next laid on the gabions, to support a second tier consisting of one row. The second tier is filled in like the first, and the earth is heaped up on top, making the gabionade nearly eight feet high. The work will be expedited by throwing up the greater part of the earth before placing the second tier. Splinter proof traverses may be made by placing three thicknesses of gabions side by side filled with earth, with a second tier of two thicknesses on top.

Fig. 42.

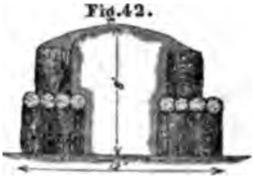


Fig. 42. Shows a Section of a Traverse.

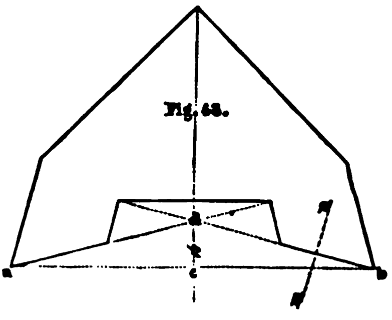


Fig. 43. Shows the plan of a Lunette with a Stoccaded Gorge A B in the form of a Bastioned Front.

83. **Enclosures for Gorges and Outlets.** A stoccade is the best enclosure for the gorge of a work. The outline (Fig. 43),

or plan of the gorge, should be a small bastion front, or a tenaille, for the purpose of obtaining a flank defence.

The trunks for the stoccade (Fig. 44) should be ten or twelve inches in diameter, and eleven feet in length. It will be best to square them on two sides, so that they may have about four inches of surface in contact. The top of the stoccade should be at least eight feet above the ground. To arrange it for defence, a banquette is thrown up against it on the interior; the height of the banquette one foot nine inches. A strip, about two feet in length, should be cut from the top of two adjacent trunks with a saw, so that when they are placed side by side there shall be an opening at top, between them, eight inches wide on the interior, and two and a half inches on the exterior; this opening, through which the muzzle of the musket is run out in firing, is termed a *loop-hole*. The distance between the loop-holes should be three feet. In this arrangement the bottom of the loop-holes will be six feet above the ground on the exterior, to prevent the enemy from closing on them to stop them up, or use them in the attack.

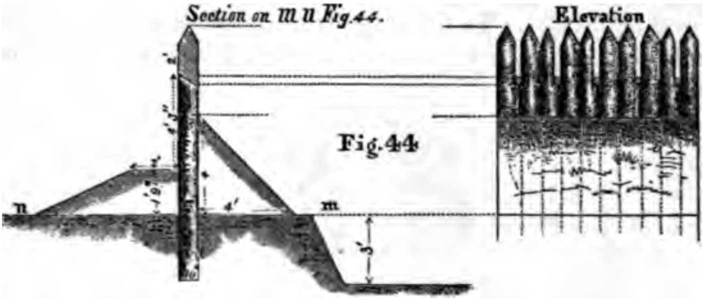


Fig. 44. Section on m n, and Elevation of Stoccade of Gorge.

About four feet in front of the stoccade, a ditch is made twelve feet wide and three feet deep. The earth from the ditch is thrown up against the stoccade, in a slope, to the level of the bottom of the loop-hole, to prevent the enemy from attempting to cut down the stoccade.

84. **Outlets** (Fig. 45) are passages made through a parapet, or an enclosure of a gorge, for the services of the work. They should in all cases be made in the least exposed part of the work. Their width need not be more than six and a half feet, when

used only for the service of the work; but when they serve as a common passage for wagons, etc., in the case of the intrenchment crossing a road, they should be at least ten feet wide.

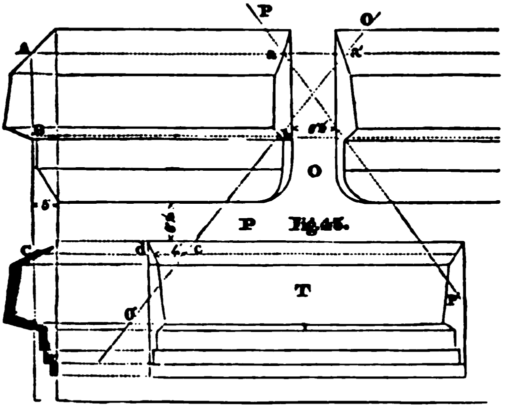


Fig. 45. Shows the Plan T of a Traverse to close the Outlet O P through a parapet. A B C is the line in which the Plane of Fire cuts the Sections of the Traverse and Parapet.

When cut through a parapet, the sides receive a slope of three perpendicular to one base, and are reveted with sods, etc.

85. A gate, termed a *barrier*, serves as an enclosure to the outlet. The framework of the barrier is made like an ordinary gate, consisting of two uprights, or *stiles*, a cross-piece, or *rail*, at top and bottom, and a *swinging bar*, or a *diagonal brace*. Upright palisades, about seven feet long and four inches thick, are spiked to the frame about four inches apart; they are finished at top with spikes. A barrier, thus constructed, will not offer a shelter to the enemy should he attempt to cut it away. The barrier is hung on hinges like an ordinary gate. The posts of the framework should be very solidly braced to support the weight of the barrier.

86. Draw-Bridge. (Fig. 45, bis.) For the usually narrow ditches of field works, either a light rolling bridge may be used for a communication, from the outlet, across the ditch; or else an ordinary wooden draw-bridge. A very simple one, and of easy construction, was proposed by Colonel Bergère of the French engineers. The bridge (Fig. 45, bis) is a light platform, *a*, *a*,' of joists and boards, long enough to span the ditch D, and so arranged as to turn around an axle at A, the crest of the scarp. At the point B, on each side of the platform, an iron gudgeon is firmly attached to it and turns in the eye of a socket at the end of the lever C B. This lever is formed of two pieces of scantling of some tough flexible wood, each about four inches square. The lever has an eye, at the middle point O, which receives a strong iron bolt that connects two ordinary gun carriage wheels. The two pieces which form the lever are firmly fastened together, as shown in the figure; a weight, consisting of shells filled with sand, or shot, being fastened at the end C, and serving as a counterpoise to the bridge. Two rails A, of heavy scantling are laid for the wheels to run upon in manœuvring the bridge; which is done simply by one or two men taking hold of the spokes of the wheels, and so, by turning them, causing them to run backwards or forwards, and thus raise or lower the bridge.

Fig. 45 bis.

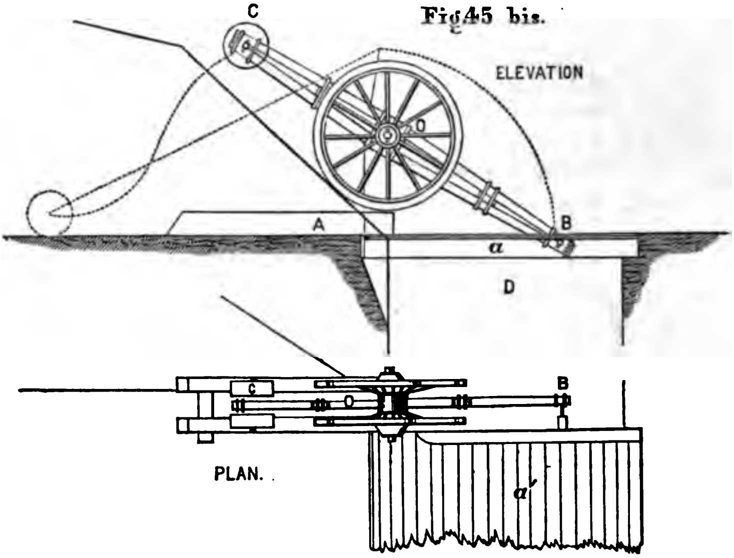


Fig. 45, bis. Plan and Elevation of Draw-Bridge for Field Works.

The outlet should be covered by a mask thrown up either on the interior or on the exterior, to prevent the enemy from firing through it into the work. A traverse (Fig. 45) is thrown across it, if placed on the interior. When placed on the exterior a small redan is constructed, just in advance of the counterscarp, of sufficient size to cover the outlet and the bridge over the ditch. The passage to the exterior may be either through the face of the redan or between one of the faces and the ditch. Sufficient space should be left between the traverse and the parapet for the passage of a gun. The length of the traverse is arranged to prevent the enemy from firing into the work, by an oblique fire through the outlet. The traverse may be of earth or of wood; in either case it should be arranged for defence to enfilade the outlet. In some cases the traverse at one end is broken forward at right angles, and connected with the parapet of the work; the space between the traverse and parapet at the other end being left open for a passage-way. A defensive stoccade with a barrier, secures this opening from surprise. It should be thrown far enough back to be out of reach of fire.

87. Safety Redoubt. In enclosed works a place of retreat, into which the troops may retire in safety after a vigorous defence of the main work, will remove the fears of the garrison for the consequences of a successful attack of the enemy, and will inspire them with confidence to hold out to the last moment.

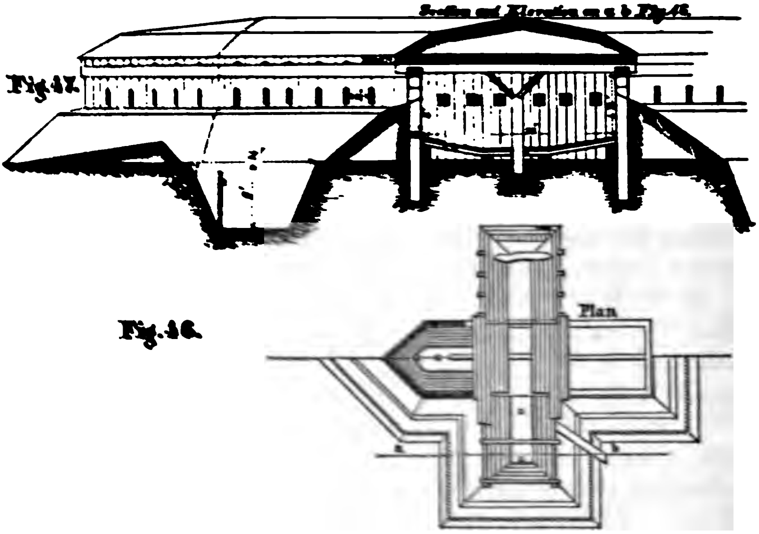
This interior work, which may very properly be termed the *keep*, can only be applied to works of large interior capacity. It may be formed of earth, or consist simply of a space enclosed by a defensive stoccade, or palisading. In either case it should be about four feet higher than the main work, to prevent the enemy from obtaining a plunging fire in it from the parapet of the main work.

The best arrangement for the keep is the construction termed the *block-house.* This work Figs. 46, 47 is made of heavy timber, either squared on two sides or four; the pieces which form the sides of the block-house are either laid horizontally, and halved together at the ends, like an ordinary log-house, or else they are placed vertically, side by side, and connected at top by a cap-sill. The sides are arranged with loop-hole defences; and the top is formed by laying heavy logs, side by side, of the same thickness as those used for the sides, and covering them with earth to the depth of three feet.

With regard to the details of the construction, the timber for the sides should be twelve inches thick, to resist an attack of musketry, and to resist field-pieces two feet, in which case the sides are formed of two thicknesses of twelve-inch timber. If

Fig. 47.

Fig. 46.



Figs. 46, 47. Show the plan and section of a block-house of upright timber. The plan is made to exhibit a portion of the top complete; the timber covering of the top; the arrangement of the cap pieces, a plan of the loop-holes, and a plan of the camp-bed. Fig. 47 exhibits, in like manner, a cross section of the block-house and ditch; with an interior and exterior elevation.

the timber is placed upright, each piece should be let into a mortise in the cap-sill; and every fourth piece of the top, at least, should be notched on the cap-sill, to prevent the sides from spreading out.

The plan of the block-house must conform to its object generally; it may be square or rectangular. If flank defences are required, its plan may be that of a cross. The interior height should not be less than nine feet, to allow ample room for loading the musket; this height will require that the timber of the sides shall be twelve feet long, in order to be firmly set in the earth. Sometimes a ground-sill is placed under the uprights, but this is seldom necessary. The width may be only twelve feet in some cases, but it is better to allow twenty feet; this will admit of a camp bed of boards on each side, six and a half feet wide, and a free space of seven feet. If cannon is to be used for the defence, the width must be at least twenty-four feet; this will allow eighteen feet for the service of the gun, which is generally ample, and six feet for a defence of musketry on the opposite side. A greater width than twenty-four feet cannot well be allowed, because the bearing would be too great between the sides for twelve-inch timber; and even for a width of sixteen feet it would be well to support the top pieces, by placing a *girder* under them resting on *shores*.

The loop-holes are three feet apart; their interior dimensions are twelve inches in height, and eight inches in width for sides twelve inches thick; and twelve inches square for sides two feet thick. The width on the exterior, for the same thicknesses, will be two and a half and four inches. The height of the loop hole on the exterior will depend on the points to be defended; it should admit of the musket being fired under an elevation and a depression. The height of the loop-hole above the exterior ground is six feet.

Vents for the escape of the smoke are made over each loop-hole, between the cap-sill and the top pieces.

The camp bed serves also as a banquette; it is placed four feet three inches below the loop hole, and has a slight slope of about eight inches inwards.

The provisions, accoutrements, etc., are placed on shelves and racks attached to the shores and girders; and in cellars in dry localities.

The block house is surrounded by a ditch, similar to the one used for a defensive stoccade. A strong door is made in one of the reëntering angles, and a slight bridge leads from it across the ditch.

88. Block-House with top Parapet It has been proposed to place a slight parapet of earth on top of the block-house. It is thought that this accumulation of earth would be too heavy for the timbers, independently of leaving but little space for the defence. Perhaps a better arrangement might be made on top, similar to a defensive stoccade, the uprights being secured at bottom, between two pieces resting on the top pieces, and held firm by an arrangement of riband pieces and braces.

It has also been proposed to place the interior and exterior rows of uprights three feet apart, and to fill in between them with closely packed earth, for a defence against artillery. This method has been tried, and was found to be less solid than the one here laid down, independently of being more difficult to construct.

The top pieces should in no case project more than twelve inches beyond the sides to admit of logs, etc., being rolled over on the enemy.

89. American Block-House. In the more recent block-houses erected in our service for the protection of bridges, railroad stations, etc, the sides and roof (Figs. 48, 49, 50) and (Figs. 51, 52) are constructed with a double thickness of logs eighteen inches in diameter, hewn to a face of eight inches where they are in contact. The inner logs are placed upright, the outward horizontal. A space is left in the outward casing sufficient for the fire from the loop-holes made through the inner. The horizontal logs above the loop-holes are held up by short uprights, mortised into them and into those just below. The ceiling is covered with earth, as shown in the section, three feet thick at the ridge and sloping towards the eaves to about six or nine inches, where it is confined by a pole plate. The earth is

Section.

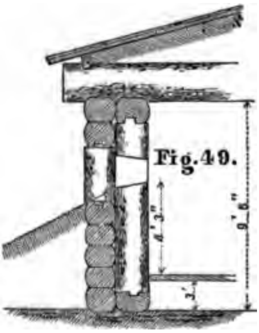


Fig.49.

Elevation.

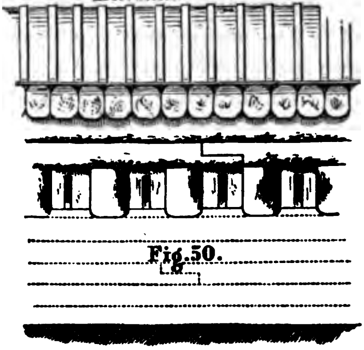


Fig.50.

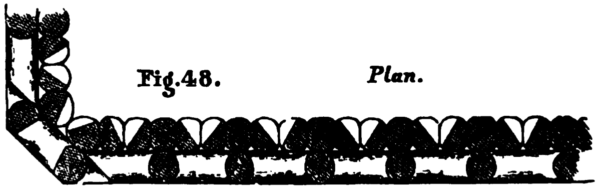


Fig.48.

Plan.

Fig. 48 shows a Plan, Fig 49 a Section, and Fig. 50 an Elevation of a Block-house of two thicknesses of logs square to eight inches on two sides. The walls from three and a half to four feet thick, to resist field guns.

protected from the weather by a board roofing. Tin or sheet iron ventilators are made through the roofing and ceiling, and a brick flue to receive the pipe of the stove used in cold weather.

The loop-holes are nearly of the same form and dimensions of those already given.

Some of these structures are built in the form of a cross, consisting of a square central chamber, twenty-four feet on a side, and of four wings of the same form and dimensions when the block-house is for cannon. An embrasure is pierced in each of the three sides of each wing to serve a single gun. The cheeks of the embrasures are faced with logs, and the mouth is secured by a musket-proof shutter with a loop-hole in it. The embrasures are below the level of the loop-holes, allowing these to be used whenever necessary.

Arrangements for magazines and store-rooms are made under the floor of the block-house in the most secure parts.

The entrance to the block-house may be either through a postern, the bottom of which is on the level of that of the ditch, a ramp leading from this level outwards, a door properly secured, and steps, forming the inner communications; or it may be arranged as shown in Figs. 51, 52, with a plank thrown across the ditch on the same level as the natural ground, the entrance to the door being masked by a double stoccade, leaving the same passage-way as that of the doorway. Loop-holes in the door and sides of the building sweep this passage.

90. Two Story Block-House. The block-house is sometimes arranged with two stories, the corners or the sides of the upper story projecting over the sides of the lower. Either of these methods is sufficient for the defence of the lower story; but the first is the best to procure a fire in the direction of its angles. It can only be used, however, as a defence against infantry.

When artillery cannot be brought to bear against the top of the block-house, it may be constructed like an ordinary floor, and be covered with nine or twelve inches of earth to guard against fire.

The application of wood to the purposes of defence is one of paramount importance in our country. A block-house, surrounded by a defensive stoccade, is impregnable to the attack of infantry if properly defended, and is therefore peculiarly suitable to either wooded or mountainous positions, where a train of artillery cannot be taken without great labor, owing to the impediments that may be thrown in its way, by rendering the roads impassable from obstructions easily obtained. In positions covered by extensive earthen works, such as those that would be required for the defence of the towns on our seaboard, and which would be occupied during a war, a defensive arrangement of the barracks for the troops, so that they might serve, in case of the main works being forced, as rallying points, under cover

Fig. 51.

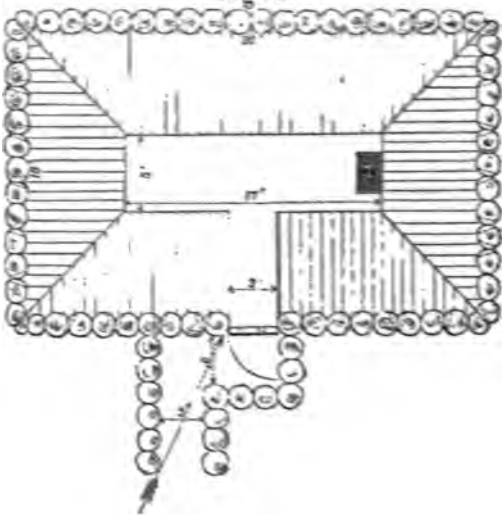


Fig. 52.

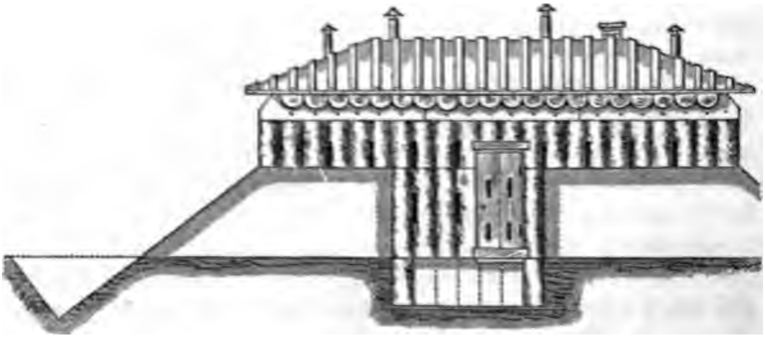


Fig. 51, Plan, Fig. 52, Elevation of Block-house of single logs, showing arrangement of entrance to Door-Way.

Fig.2.

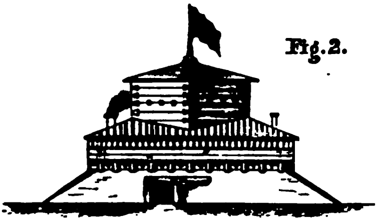


Fig.3.

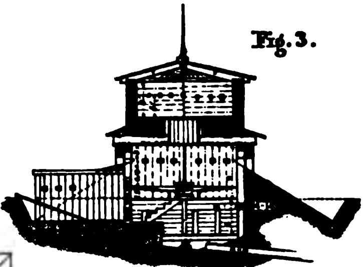


Fig.1.

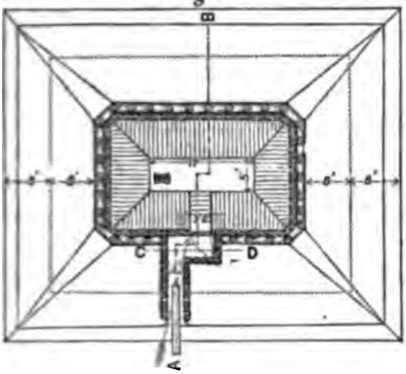


Fig. 1 shows a Plan, Fig. 2 an Elevation, and Fig. 3 a Section of a Block-House of two stories, the walls from three and a half to four feet thick.

Fig.4.

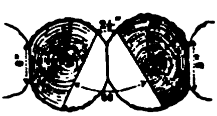


Fig.5.

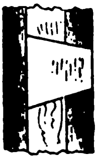


Fig. 4, Plan, Fig. 5, a Side Elevat'on of a Loop-hole for Block-house, lower story.

Fig.6.

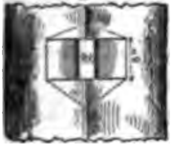


Fig.7.

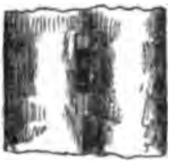


Fig.8.

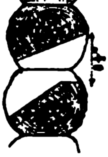


Fig. 6, Interior Elevation. Fig. 7, Exterior Elevation of Loop-holes for upper Story. Fig. 8, Section.

Figs. 1, 2, 3, etc., represent the chief details of the two-story block-houses that have been adopted for the defence of railroad stations, bridges, etc., along the line of communications of General Sherman's army. From experiments made upon them, the lower story, with its double row of heavy logs from three and a half to four feet in thickness, is regarded of sufficient strength to resist the field artillery usually taken with cavalry in their raids.

of which the main body of troops may retreat with safety, is a subject that commends itself to the serious attention of the engineer. From the details already entered into, an efficient combination for this purpose will suggest itself to the reader, without entering farther into particulars.

91. Ditch Defences. The surest defence for a ditch is a good flanking arrangement of the work itself; but as this is, in many cases, impracticable, owing either to the relief, or to the plan, flank defences must be procured by a construction made in the ditch. Several methods may be resorted to for this purpose, termed *caponnières*, *scarp*, and *counterscarp galleries.*

92. Caponnières. The caponnière is a work made across the ditch, and may be either single or double. A single caponnière is nothing more than a defensive stoccade, or palisading, made at the extremity of a ditch, as in the case of a redan. It will obviously be of no service, unless the enemy is forced to attack it in front.

A double caponnière (Fig. 53) is arranged to fire in two directions, and is usually placed at the middle of the ditch which it is to protect. It is made in all respects like a block-house with upright sides; its width may be only eight feet, and its height the same.

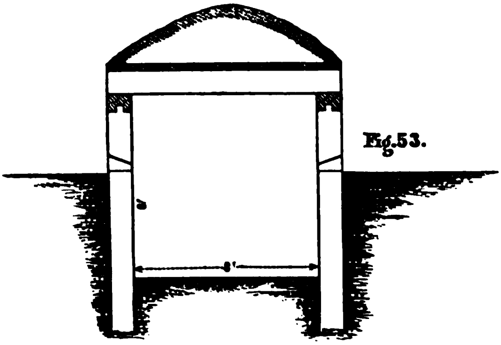


Fig.53.

Fig. 53. Section of Caponnière for Ditch Defence.

The bottom of the caponnière may be on the same level as the ditch, or below it; in the latter case, the loop-holes should not be more than eighteen inches above the level of the ditch, to prevent the enemy from using them against the assailed within.

In the former, a small ditch should be made round the caponnière, and the earth from the ditch be thrown against its sides.

The plan of the caponnière (Fig. 54) should be arranged to admit of being flanked by a defensive stoccade, placed at the foot of the scarp; for this purpose the end next to the counterscarp should be in the form of a salient flanked by the stoccade. To prevent the enemy from jumping on the caponnière, from the crest of the counterscarp, a space of at least twelve feet should be left between the two. Moreover, the top of the caponnière should be covered from the enemy's artillery, either by the counterscarp crest or by a glacis.

Fig. 54

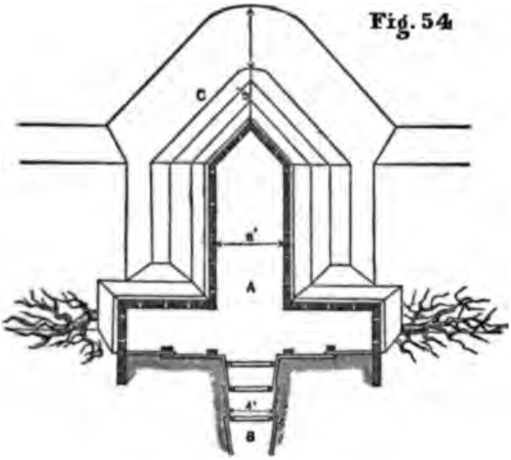


Fig. 54. Plan of Caponnière A, with a Postern, B leading to it.

The communication to the caponnière, from the work, may be by a timber gallery under the parapet, formed of frames and a sheeting, similar to the construction used for a powder magazine.

93. Counterscarp Gallery. The counterscarp gallery (Fig. 55) consists of a framework, covered on top with a sheeting, which is placed within the counterscarp at the salients. The front of the gallery is made of nine or ten-inch scantling, placed upright, and arranged with loop-hole defences; these pieces are connected at top by a cap-sill. Cross-pieces are notched on the cap-sill, about three feet apart; they are supported by shores placed four feet from the front-piece. The cross-pieces may project three feet beyond the shores, and, if necessary, be braced from the shores. The gallery is covered on top by one and a half inch sheeting; and behind in a similar manner, but only to the height of five feet above the bottom. This arrangement gives a free space behind the back sheeting for the play of the rammer in loading. The height of gallery may be only seven feet; its width, according to the foregoing arrangements, is four feet. It should be covered on top by at least three feet of earth. The level of the gallery should be the same as the ditch; and there should be a small ditch in front of it, to prevent the enemy from closing on the loop-holes, or obstructing their fire by filling the ditch in front of them by means of sand bags, fascines, etc. The entrance to the gallery is by a narrow door.

Fig. 55.

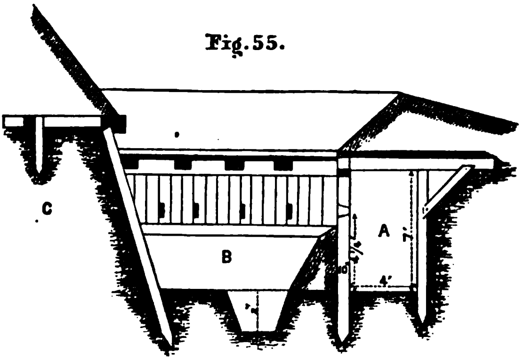


Fig. 55. A Section, B Elevation of a Counterscarp Gallery for a Work with a Reveted Scarp, C.

94. Scarp Gallery. A scarp gallery, either for musketry or for one or two pieces of cannon, may be constructed to procure a flank fire in ditches with dead angles. These galleries may be made in all respects like a double caponnière; the bottom of the gallery being sunk low enough to allow the greater portion of the ditch to be swept. As the top of the gallery must support that portion of the parapet of the work above, it must be firmly shored by strong timber. The rear of the gallery must be open, and there should also be an escape for smoke at the berm of the parapet above the gallery.

A construction of a like character may be used to form a blind for one or two guns which it may be particularly desirable to place under cover from an enemy's artillery. The sides of the blind may be farther secured by placing against them either gabions or sand bags.

CHAPTER VIII.

ACCESSORY, OR SECONDARY MEANS OF DEFENCE.

95. Disposition of Obstacles. The means employed as *accessory* usually consist of artificial obstacles, so arranged as to detain the enemy in a position where he will be greatly cut up by the fire of the work.

Anything may be regarded as an obstacle to the enemy by which his attention is diverted from the assailed to his own situation; but no obstacle will be of much service to the assailed which is not within good striking distance of his weapons. *The proper disposition, therefore, of obstacles, is in advance of the ditch within short musket range.* Here they delay the assailant under fire, and give the assailed a feeling of more security as the assailant is kept further off.

Marshes, water-courses, wet ditches, precipices, etc., may be regarded as obstacles, if they are sufficient in themselves to stop the enemy's progress. But, however strong, they are not solely to be relied on; as the strongest natural position may be carried if not vigilantly guarded.

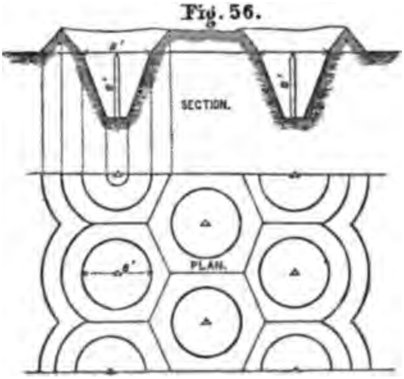
96. Obstruction of Approaches. In placing the ground around a work in a defensive attitude, every means should be taken to reduce to the smallest possible number the points by which the enemy may approach; so that, by accumulating the troops on the weak points, a more vigorous defence may be made. In making this arrangement, equal care should be given to everything that, affording a shelter to the enemy, would enable him to approach the work unexposed to its fires. To prevent this, all hollow roads, or dry ditches, which are not enfiladed by the principal works, should be filled up, or else be watched by a detachment, covered by an advance work. All *trees, underwood, hedges, enclosures,* and *houses,* within cannon range, should be cut down and levelled, and no stumps be allowed higher than two feet. Trees beyond cannon range should not be felled; or if felled, they should be burnt, to prevent the enemy's movements being concealed.

If there are approaches, such as *permanent bridges*, *fords*, and *roads*, which may be equally serviceable to the assailed and to the enemy, they should be guarded with peculiar care, and be exposed to the enfilading fire of a work especially erected for their defence.

97. Classes of Obstacles. The principal artificial obstacles are *trous-de-loup*, or *military pits*; *abattis*; *palisades*; *fraises*; *stoccades*; *chevaux-de-frise*; *small pickets*; *entanglements*; *crow's-feet*; *inundations*; and *mines*.

98. Trous-de-loup. (Fig. 56.) These are pits in the form of an inverted truncated cone, or quadrilateral pyramid; their diameter at top is six feet, their depth six feet, and width at bottom eighteen inches. A stake is, in some cases, planted firmly in the bottom, its top being sharpened, and the point a few inches below the upper circle.

Fig. 56.

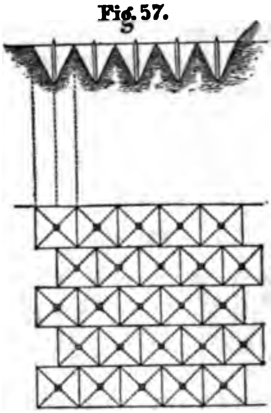


Trous-de-loup are generally placed in three rows, in quincunx order, a few yards in front of the ditch. They are readily laid out by means of an equilateral triangle, formed of cords, the sides of the triangle being eighteen feet; the angular points mark the centres of the pits. The earth taken from them is spread over the ground between them, and is formed into hillocks to render the passage between as difficult as possible. If brushwood or light hurdles can be procured, the pits may be made narrower, and covered with the hurdles, over which a layer of earth is spread.

Trous-de-loup are sometimes placed in the ditch; in this case their upper circles touch.

Small holes of an inverted pyramidal shape (Fig. 57), with stakes, may be used for trous-de-loup.

Fig. 57.



These obstacles are principally serviceable against cavalry.

The term *rifle-pit* has lately come into use for trous-de-loup large enough to hide a sharp-shooter in, and, by a small cover in front, enable him to use his arms.

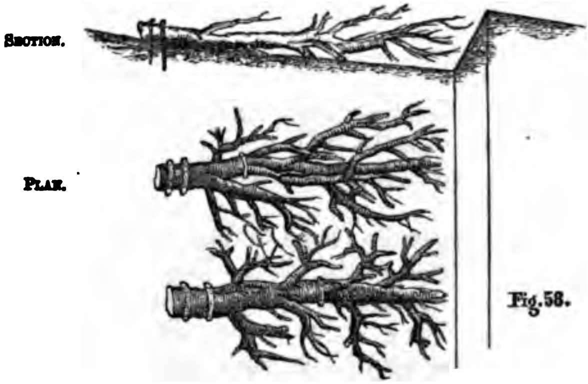


Fig. 58.

99. Abattis. (Fig. 58.) The large limbs of trees are selected for an abattis. The smaller branches are chopped off, and the ends, pointed and interlaced with some care, are presented towards the enemy. The large end of the limb is secured to the ground by a *crotchet-picket*, and may be partly imbedded to prevent its being readily torn up.

One of the best methods of forming an abattis, and which is peculiarly adapted to strengthen the skirts of a wood occupied by light troops, is to fell the trees so that their branches will interlace, cutting the trunk in such a way that the tree will hang to the stump by a portion uncut. The stumps may be left high enough to cover a man in the act of firing.

Abattis are placed in front of the ditch ; in this position they must be covered from the enemy's fire by a small glacis. They are sometimes placed in the ditch against the counterscarp.

This is an excellent obstacle in a wooded country, and admits of a good defence, if a slight parapet is thrown up behind it. The parapet may be made of the trunks of trees laid on each other, with a shallow ditch or trench behind them ; the earth from which is thrown against the trunks. In an open position it may be relied on as a security against a surprise, particularly by cavalry.

100. Palisades. (Fig. 26.) A palisade is a stake about ten feet long, and of a triangular form, each side of the triangle being eight inches. The trunks of straight trees should be selected for palisades. The diameter of the trunk should be from sixteen to twenty inches. The trunk is sawed into lengths of ten and a half feet, and is split up into rails, each length furnishing from five to seven rails. The palisade is pointed at top : the other extremity may be charred if the wood is seasoned, otherwise the charring will be of no service. A *palisading* is a row of palisades set in the ground, either vertically, or slightly inclined towards the enemy. To plant the palisades, a trench is dug three feet deep ; they are then placed about three inches asunder, with an edge towards the enemy. Each palisade is nailed to a strip of thick plank, termed a *riband*, placed horizontally about one foot below the ground ; another riband is placed eighteen inches below the top. The earth is firmly packed in the trench.

A palisading is sometimes used as a primary means of defence, particularly for low works. A banquette is thrown up for this purpose against it ; the tread of the banquette being six feet below the top of the palisading, and four feet three inches below the upper riband.

As an obstacle in flanked works, it is best placed at the foot of the counterscarp; the points being twelve inches below its crest, or else covered by a small glacis. In this position the palisading fulfils all the conditions of an efficient obstacle; it is under the fire of the work; covered from the enemy's fire; will not afford a shelter to the enemy; and cannot be cut down without great difficulty.

101. An inclined palisading (Fig. 59) is sometimes placed in

Fig. 59.

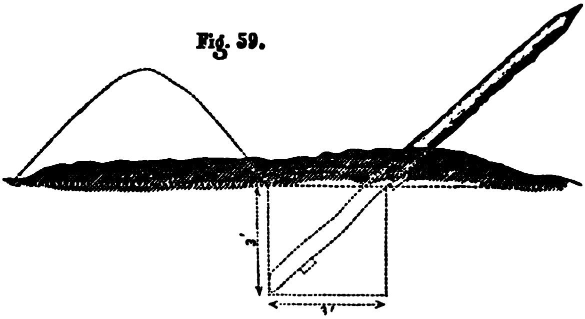


Fig. 59. Section of inclined Palisading, showing by the dotted lines the trench and earth removed from it.

Fig. 60.

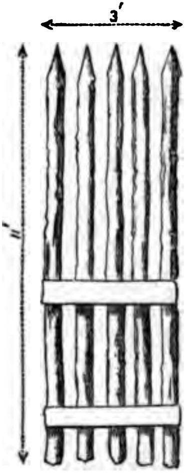


Fig. 60. Elevation of a panel of the Palisading.

an advanced position in front of an ordinary trench to secure it from surprise. This was done to secure a line of trench at the siege of Fort *Wagner*. The palisading was made at the depôt in panels (Fig. 60) of four or five palisades, cut from pine saplings varying from four to eight inches in diameter, those above five inches being split in two, and placed with the bark side upwards. The spaces between the palisades were left only small enough to prevent a man forcing his body through them.

102. Fraise. (Fig. 27.) This obstacle is formed of palisades, placed in juxtaposition, either horizontally or slightly inclined. The best position for a fraise is on the berm, or a little below it, so as to be covered by the counterscarp crest. The part of the fraise under the parapet is termed the *tail*, and is about five feet long. To make a fraise, a horizontal piece of four-inch scantling, termed a *cushion*, is first laid parallel to the berm; each palisade is nailed to this, and a thick riband is nailed on top of the fraise near the end.

The point of the fraise should be at least seven feet above the bottom of the ditch, and should not project beyond the foot of the scarp, so as not to shelter the enemy from logs, stones, etc., rolled from the parapet into the ditch.

The fraise is a good obstacle for works without flanking, as a redoubt, etc.

103. Stoccade. Trunks of small trees, from nine to twelve inches in diameter and twelve feet long, are selected to form a stoccade. They are planted in juxtaposition, in a similar manner to a palisading, and are used for the same purposes. The manner of arranging a stoccade, which is also sometimes termed a *picket*, as a primary defence, will be described in another chapter.

104. Chevaux-de-frise. A cheval-de-frise (Fig. 61) consists of a horizontal piece of scantling of a square or hexagonal form, termed the *body*, about nine feet long, which is perforated by holes two inches in diameter and five inches apart; round staffs, ten feet long and two inches in diameter, termed *lances*, shod with iron points, and inserted into the body, so as to project equally from it. At one end of the body a ring and chain are attached; at the other a hook and chain; for the purpose of attaching several together, forming a chevaux-de-frise.

The square is the best form for the body; it requires only five-inch scantling, whereas the hexagon will require twelve-inch timber.

The chevaux-de-frise is not much in use as an obstacle, owing to the difficulty of making it. It is a good defence against cavalry; and on rock may supply the place of palisades; but even here an abattis would be more effective, and generally more readily formed.

Fig. 61.

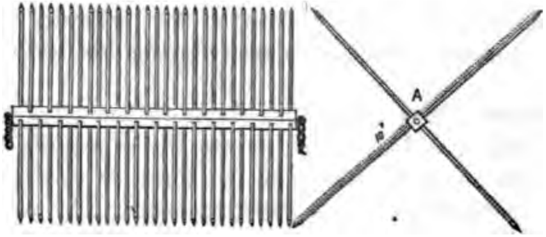


Fig. 61. Section A and Elevation B of Cheval-de-frise.

A chevaux-de-frise formed of sword blades for lances has been found a formidable obstacle.

105. Small Pickets. This obstacle (Fig. 28) consists of straight branches of tough wood cut into lengths of two and a half or three feet. They are driven into the ground in a quincunx order, about twelve inches apart, and project irregularly above it, not more than eighteen inches. Interlaced with cords, wire, grape-vines, brambles, prickly shrubs, etc., they form an excellent *entanglement.*

106. Crow's-Foot. This is formed of four points of iron, each spike about two and a half inches long, and so arranged, that when thrown on the ground one of the points will be upwards. They are a good obstacle against cavalry, but are seldom used. Boards, with sharp nails driven through them, may supply the place of crow's-feet. The boards are imbedded in the ground, with the sharp points projecting a little above it.

107. Inundations. This obstacle is formed by damming back a shallow water-course, so as to make it overflow its valley. To be effective, an inundation should be six feet deep. When this depth cannot be procured, trous-de-loup, or else short ditches, placed in a quincunx order, are dug, and the whole is covered with a sheet of water, which, at the ditches, must be at least six feet in depth.

The *dams* used to form an inundation are made of good binding earth, or of crib-work of logs filled in with stone, gravel, and earth, or of successive layers of fascines and gravel. If the dams are to stand for some time they may be faced on the upper side with boards. They cannot, in general, be raised higher than ten feet; they need not be thicker than five feet at top, unless they are exposed to a fire of artillery, in which case they should be regulated in the same way as a parapet. The slope of the dam down stream should be the natural slope of the earth; but up-stream the slope should have a base twice that of the natural slope. *Sluices* are made in the dams, in a similar manner to the sluices of a mill-dam, for the purpose of regulating the level of the water in the pool above, in case of heavy rains. *Waste-weirs* are also serviceable for the same purpose, but unless carefully made they may endanger the safety of the dam.

The distance of the dams apart will depend on the slope of the stream. The level of each pool should be at least eighteen inches below the top of the dam, and the depth of water below each dam should be at least six feet. These data will suffice to determine the centre line, or *axis* of each dam.

Artificial inundations seldom admit of being turned to an effective use, owing to the difficulties in forming them, and the ease with which they can be drained by the enemy. But when it is practicable to procure only a shallow sheet of water, it should not be neglected, as it will cause some apprehension to the enemy. In some cases, by damming back a brook, the water may be raised to a level sufficient to be conducted into the ditches of the work, and render some parts unassailable. The ditches in such cases should be made very wide, and to hold about a depth of six feet. During freezing weather the ice should be broken in the middle of the ditch, and a channel of twelve feet at least be kept open, if practicable. The ice taken out should be piled up irregularly on each side of the channel; and, as a farther precaution against a surprise, water should be thrown on the parapet to freeze.

In a system of inundations the dams should, as far as practicable, be built at points the least exposed to the fire of the assailed. The head of each dam, on the side of the enemy, should be secured from surprise by a redan, stoccade, or other defence, and the dam itself and its approaches should be swept by musketry and artillery.

108. Mines. Attempts at applying mines to the defence of field works have seldom proved successful, owing to the rapid character of the assault, from which the mines are usually sprung too soon or too late: so that the only effect that can be counted upon for their use is the panic they may create.

109. Stone-Fougasse. There is one species of mine denominated a *stone-fougasse*, which it is thought might be successfully applied to the defence of the ditches and salients of field works. To make this mine (Fig. 62), an inclined funnel-shaped excavation is made to the depth of five or six feet; at the bottom of the funnel a box containing fifty-five pounds of powder is placed, with which a *powder-hose* communicates. A strong shield of wood, formed of battens well nailed together, is placed in front of the box; and three or four cubic yards of pebbles, or an equal weight of brick-bats, or other materials, are filled in against the shield. Earth is then well rammed around the shield on top and behind, to prevent the explosion from taking place in the wrong direction. A fougasse of this size, when sprung, will scatter the pebbles over a surface sixty yards in length and seventy yards in breadth.

Fig. 62.

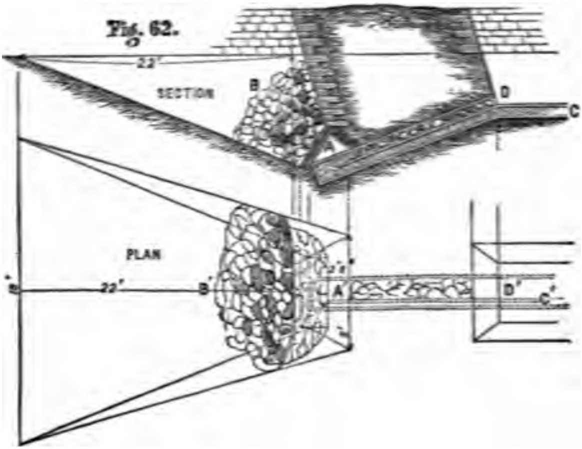


Fig. 62. Plan and Section through the axis of a Stone-Fougasse. D D' Ditch of work at the Salient; A, A' Shield above charge of powder; B, B' Stone; C, C' Train leading to charge at A, A'.

110. Torpedoes. Small casks and large shells loaded with powder, termed *torpedoes*, and so arranged as to be exploded by friction, or a blow on a fulminating compound, have been lately used as mines with some success. The fulminate is exploded either by a plunger fixed into a water-tight tube screwed into the cask, which is forced down by a person treading on a light board resting upon it and covered lightly with earth, or else in the same way by friction as a cannon is fired.

CHAPTER IX.

ADAPTATION OF FIELD FORTIFICATION TO IRREGULAR AND VARIED SITES.

111. General Considerations. The skill of the engineer is chiefly shown in adapting the resources of his art to the great variety of topographical features met with in the positions that an army is necessarily obliged to occupy when acting on the defensive. No less skill is called for on the part of the general in the selection of his defensive points, as no engineering skill can remedy, in other than a defective manner, a position which is strongly commanded by points which the assailed can occupy within good cannon range, or the flanks of which can be readily turned. To fortify similar positions demands a degree of effort in the inverse ratio of their strength, and for the most part is but labor in vain.

112. Strategical and Tactical Considerations. Two principal questions present themselves in a strictly defensive war; the one *strategical*, the other *tactical*. The first is based upon the general features of the territory to be defended as affecting the operations of the assailing force, and the system of warfare the best adapted to the assailed; the second on the particular topographical features of the positions where resistance is to be made.

113. Frontier Defences. The first attention will naturally be given to the system of defence for the frontier, whether one or more strong points shall be alone occupied from which the assailed can be observed; or whether a continued line of natural and artificial obstacles shall be presented to obstruct the movements of the invading force. Although opinion is against the latter method, the question is one that cannot be decided in an absolute manner. The numbers and quality of the army on the defensive; political as well as military considerations; the character of the frontier; the facilities for the rapid concentration of the troops; and the security of the lines of retreat has an important bearing upon it and demands the most careful consideration.

That a very extended line is necessarily a weak one is generally admitted; still a system of continued lines, in a country difficult to penetrate, may be used with advantage, and if weak when assailed by a strong force, may serve as an obstruction to a weak one, and be particularly serviceable against raids. Such a line may be made to play the same part as the lines thrown up in siege operations to prevent the garrison besieged from obtaining succor or supplies by detachments trying to penetrate them.

114. Tactical Considerations. The tactical considerations are the same in the application of field fortifications to a position as for the distribution of troops for its defence. Their principal value depends upon the character of the site itself. If it has the qualities of a good defensive field of battle, and lends itself to such a disposition of intrenchments as the troops themselves would naturally assume, then the essential tactical considerations can be secured. In all such cases both the plan and the command of the system employed must be subordinate to the site; to attempt more than this would require time and means far beyond the command of an army in the field.

115. Military Positions. Positions derive their great importance from the influence of fire-arms in the decision of battles; for whatever enables one party to deliver its fire with effect against the other, whilst it, at the same time, remains sheltered in any degree from that of its adversary, places the advantage, all other things being equal, greatly on its side; and it is this advantage which should be principally kept in view in selecting a position.

Woods, *commanding heights*, *precipices*, and *villages*, constitute the strong points of a position. They serve as points of support against which the wings of the army rest; or else, by covering parts of the front, they serve as the key points in the defence.

A wood, if properly intrenched, covers the infantry from the attacks of cavalry; conceals its manœuvres, and enables it to deliver its fire without being exposed to that of the enemy.

Heights, by giving a commanding view of the surrounding ground, increase both the range and the effects of fire-arms;

whilst they, at the same time, serve to screen the troops behind them until they are required to be brought into action. Precipices offer similar advantages to heights, and are moreover unassailable.

Villages serve as secure shelters for detachments, which, by their fire, cover the manœuvres of the troops in their rear; and, if properly intrenched, will cause the enemy great loss in his effort to force his way into them.

Rivers, *marshes*, *hollows*, and *ravines*, are the most unfavorable features of a position, because they may prevent a free circulation from one point to another, and thus impede the manœuvres; and they are exposed to the full fire of the enemy. They may however be of service when they are so placed as to support the wings, or, when the position being too extended for the number of troops, they render parts of the front unassailable.

The best positions are those which, being in due proportion to the force by which they are occupied, command all the surrounding ground within cannon range, the ground descending in a gentle slope to the front, presenting woods, villages, etc., to support the wings and cover parts of the front, and admitting of a free circulation from one point to another, with secure communications in their rear in case of retreat. If with these advantages, they present marshes, or other obstacles, which will embarrass the enemy's movements, and force him to advance in column, exposed to the fire and free manœuvres of the assailed, they will unite everything desirable in a favorable field of battle.

Intrenched Camps. Troops should always be encamped in order of battle, to avoid the consequences of a surprise. When a camp is fortified, it is termed an *intrenched camp*. The same rules and general principles apply to the choice of a site for a camp, and the manner of fortifying it, as to other positions.

116. Mountainous Sites. The crests, and gorges, are the most important military features of a prominently marked mountainous position. It is through the latter that the roads are made, and the former, from their elevation, command the latter. The crests should therefore never be abandoned to the enemy, although from their position, or distance, they may not directly overlook the gorges; for, independently of the real advantage of position, which the enemy would thus acquire, he would possess a relative advantage in the moral effect produced on troops when they find themselves in a commanded position.

If the base of the mountain does not stretch out too far from the summit to admit of a sure retreat on the latter, works may be thrown up for the defence of the base, with intermediate works between the base and the summit placed on the secondary ridges, or other commanding points. But if the distance between the summit and the base is great, and particularly if it is decided beforehand to retreat upon the summits, in case of disaster, then the base should be disregarded.

The works thrown up for the defence of the summit should be laid out on the brow of the height, for the purpose of overlooking and guarding its sides. As has been already stated, the plan and relief of the defences will be subordinated to the features of the ground. Where the surface along the crests is undulating, presenting salient and reëntering parts, consisting of spurs and ravines more or less prominent, the salient points should be occupied by works with a good relief, and otherwise strengthened by passive obstructions to the assailant's advance, as from their position a broad flanking sweep of the surface for artillery can be obtained for the defence of the approaches upon the collateral salients. The reëntering portions may be occupied with defences of a weaker profile, as their position is stronger and it is from them that a strong fire of musketry and of the lighter field guns can be brought to bear upon the ground directly in front of the salients adjacent to them.

The cremaillère line (Figs. 16, 63), and the redan line with long curtains broken forward, so as to form a tenailled combination with alternate long and short branches (Figs. 14, 15), both

Fig. 63.

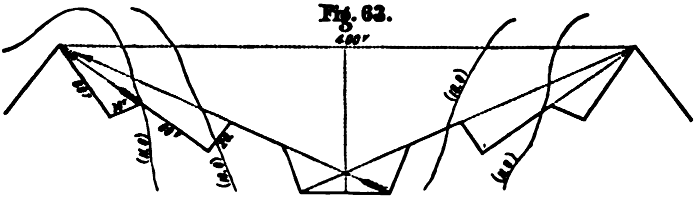


Fig. 63. Plan of Cremaillère Line across a hollow or valley. The curves (10.0) and (11.0) are the horizontals of the surface.

lend themselves better than most other combinations to a configuration of ground of this description.

Very steep slopes will not admit of a defence with artillery, because the gun cannot be fired under a much greater depression than one-sixth, and unless the shot take effect the enemy will be inspirited to advance, confiding in the safety of his position. In slopes of this character the works may consist simply of a parapet (Fig. 64), in the form of a glacis, without any ditch, the earth for the parapet being taken from an interior trench; in some cases a dry stone wall may be substituted for an earthen parapet. An abattis may be formed in front of the parapet within close musket range; and heavy round logs, or large masses of rock, be arranged along the parapet, ready to be rolled over on the enemy should he break through the abattis. Steep escarpments of rock are generally considered inaccessible; but those points should never be left to their own strength. It is always prudent to post a small detachment to frustrate an attempt of the enemy to surprise them.

Fig. 64.

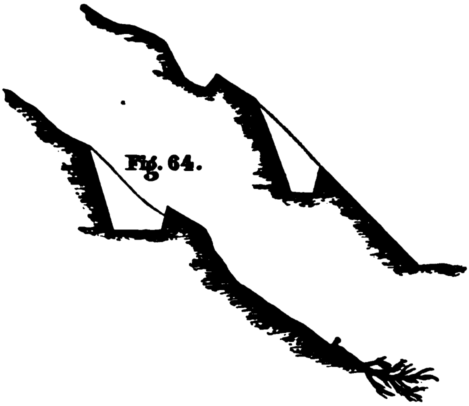


Fig. 64. Sections of Trenches on Hill Sides or Sloping Ground.

A steep natural slope (Figs. 65 bis, 66 bis) may be readily made inaccessible by cutting away the face of the eminence.

It may, in some cases, be indispensably necessary to guard certain points at the base of a mountain, as, for example, where the base is washed by a river, over which there is an important ferry. Under such circumstances the point to be guarded should be protected by a strong work; and a chain of posts, placed on the most commanding points between the summit and the base, should connect the two. These posts should, when practicable, be placed in defensive relations, and in all cases their fire should sweep all the ground between the two principal points. The interior of the posts most advanced should be exposed to the fire of those in their rear, in order that the enemy may be driven out, should he succeed in forcing his way into any one. As these posts will require a considerable detachment for their defence, care should be taken not to multiply their number unnecessarily, and never at the expense of the main defence.

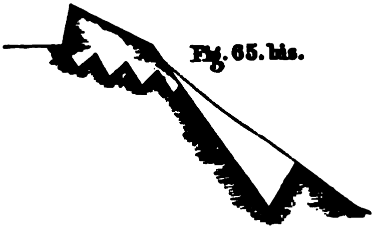


Fig. 65. Section of a Parapet and Ditch on a Steep Slope.

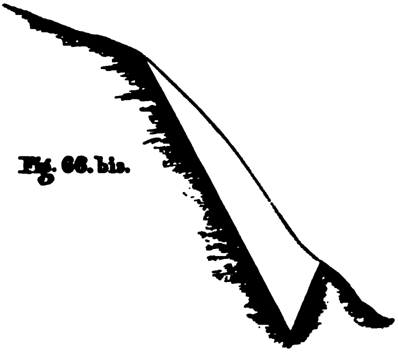


Fig. 66. Section of an Escarped Steep Slope.

All communications, leading through the mountains, should be carefully guarded, both at their outlets and at the most suitable intermediate points for defence; otherwise the most respectable positions will be liable to be turned by the enemy. If the communications are not of use to the assailed, they may be barred by a line of abattis, or by an artificial inundation, etc.;

and they should be watched by a detachment of light troops, whose retreat on the main works should be secured in case of an attack by superior forces.

If the communications are of use to the assailed they should be defended by intrenchments, which should command and enfilade them in the most effectual manner.

117. Forests. An abattis is the natural intrenchment of forests. The position of the abattis will depend on circumstances. If light troops are in observation in advance of the forest, they may be covered by a line of abattis, to prevent a surprise, and to enable the corps, if driven back, to retire under cover of the forest. Other lines of abattis may be formed at suitable points in the forest itself. If the forest is in front of intrenchments, the trees must be felled within cannon range, and an abattis be formed.

118. Marshes. An impassable marsh, or bog, may serve to render a weak point unassailable, if the enemy can neither flank nor turn it. Like all points secured by natural obstacles, it should be vigilantly guarded to frustrate any attempt to cross it by surprise. As the position behind a marsh may be regarded as unassailable, the works in its rear require but the slightest relief.

119. Rivers. The works planned for the defence of a river will depend on the object to be attained, whether it be simply to prevent the enemy from crossing, or to give the assailed the means of a secure communication with the opposite shore.

The points most favorable to the passage of the enemy are fords; and when the river is not fordable, the points where an elbow is formed, the reëntering being towards the enemy. To guard these weak points, works should be placed in a suitable position to prevent the enemy from approaching the opposite bank; and in the case of a ford, every obstruction should be accumulated on these, and the plan of the works (Fig. 65) should be so arranged that their fire can be concentrated on the ford; and, if the assailed have cavalry, a free space should be left between the water and the works for the cavalry to act on; the object being to charge the enemy whilst crossing the ford in disorder.

120. Bridge Heads. To keep open a free communication with the opposite shore, it will be necessary to throw up works there of sufficient strength to allow the assailed time to effect a safe retreat, should they be attacked by superior forces. As these works serve to cover the bridges in the rear, they are termed *têtes-de-pont*, or *bridge-heads.* The best points to erect a bridge-head are the bends, or elbows of the river, the reëntering being towards the assailed. The reasons for selecting these points are, that the bridge-head may be protected by a good flank and cross-fire from the opposite shore, which from its shape is most favorable for this purpose; secondly, from the manner in which elbows are formed, the point occupied by the bridge-head will commonly be commanded by the opposite shore, and should the enemy succeed in obtaining possession of the bridge-head, he will have all the disadvantages of a commanded position; thirdly, the elbow is not only unfavorable to the enemy, by preventing him from placing a battery in a position to destroy the bridge, but it also may prevent floating bodies, thrown into the current by the enemy with the same view, either by their shock, or by fire, from coming directly in contact with the bridge, as the chances are, that those bodies will strike one or the other shore before reaching the bend.

Fig. 65.

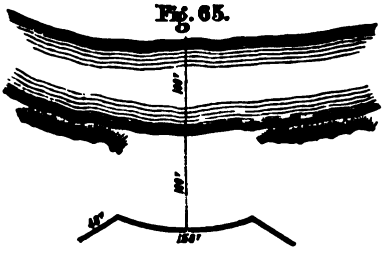


Fig. 65, bis. Plan of a Curved Trench with Straight Wings to defend a Ford.

The plan of a bridge-head should be carefully studied on the ground; and it should, as far as practicable, satisfy the following conditions:

1st. Admit of a defence until all the troops have effected a safe passage.

2d. Cover the bridge from the enemy's artillery; so that the retreat may not be cut off by the destruction of the bridge.

3d. Be suited to the end in view; if, for example, its object is to afford the means to small detachments of making incursions on the opposite shore, a small unimportant work will be all that is required. But if a large force is to pass either in retreat or to act offensively, then the works should be arranged with wide intervals to allow the troops to debouche in mass and display readily in order of battle.

4th. The flanks of the works should rest upon the banks to prevent their being turned; and, when practicable, they should be protected by flanking arrangements from the opposite shore.

5th. A strong interior redoubt should secure the bridge against an attempt on the part of the enemy to obtain possession of it by storming the works.

The practicability of obtaining flanking arrangements from the opposite shore will materially affect the plan of the bridge-head. If the breadth of the river is over one hundred yards, not much reliance can be placed on a flanking arrangement for musketry; and if the breadth is from six hundred to eight hundred yards, it will still admit of a very effective flank fire of artillery, but not greatly beyond this. For an unimportant work, therefore, which can be flanked by musketry from the opposite shore, a redan or a lunette will be a very suitable form; and if the work can only be flanked by cannon, a priest-cap (Fig. 66), or a redan, with *crotchets*, or flanks, near the extremities of the faces, and perpendicular to them, arranged for musketry, will be a very suitable form.

Fig. 66.

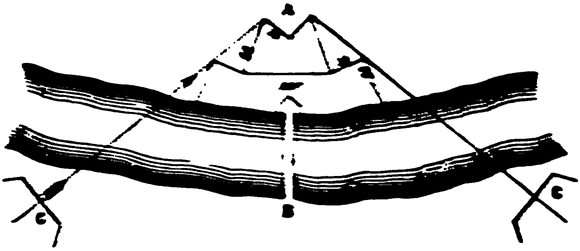


Fig. 66, bis. Plan of a Priest-Cap, A, for a *Tête-de-Pont* for a single bridge B; c c, Batteries.

Neither of these works, however, admits of sufficient strength to cover a very important point, whose loss might compromise the safety of an army, or the success of a campaign. The best arrangement for this purpose is either a *horn-work* (Fig. 67), a *simple* or a *complex crown*.

The horn-work, like the priest-cap, is best adapted to a position where the shore for some distance is nearly a straight line.

Fig. 67.

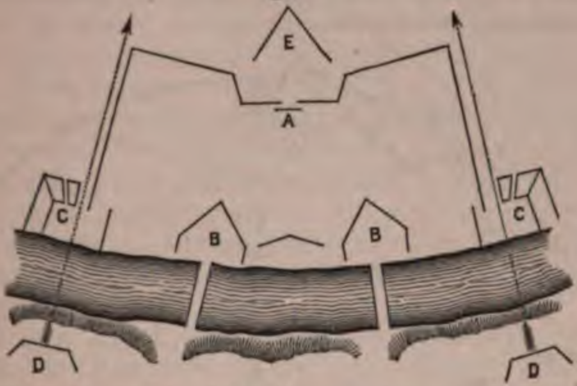


Fig. 67. Plan of a Horn-work *Tête-de-Pont.* A Traverse to cover outlet in the curtain; B B Stoccade head of bridge; C Outlets on the Flanks; E Redan covering Outlet at A; D Batteries.

It consists of a bastioned front (Fig. 67), nearly parallel to the shore and at a suitable distance from it to give the work sufficient interior capacity, and of two wings which close the flanks. When the flanking from the opposite shore is inefficient, a crotchet is added to each wing to defend its ditch and sweep in flank the approach to it. This work is only suitable where a large detachment holds the point it defends.

The simple crown (Fig. 68) consists of a central bastion, and two half bastions near the banks. In planning this work, the flanks which protect the central bastion should be longer than the other two, as it is hardly probable that the enemy will attempt an attack on any other point but the salient. The batteries on the opposite shore should sweep the ground immediately in front of the faces, and cross their fire in advance of the salient.

The complex crown-work consists of a polygon of three or more sides, on each of which a bastion front is constructed.

If the bridge-head is to cover the manœuvres of a large army, either advancing or retreating, a strong simple crown (Fig. 68), with a system of detached lunettes, about six hundred yards in front of it, presents a very suitable arrangement. The lunettes may be arranged as in the system of General *Rogniat.* The central bastion of the crown-work should be armed with a strong battery of heavy guns to protect the lunettes; and heavy batteries, on the opposite shore, should sweep the ground between the lunettes and crown-work.

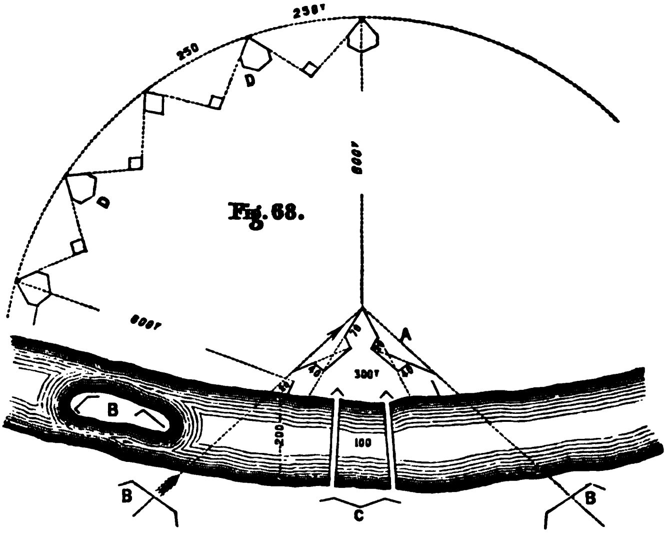


Fig. 68.

Fig. 68. Plan of a Tête-de-Pont of a Single-Crown Work A, with Detached Works, D D. B B, Batteries.

If there are islands in the river near the works, they may be fortified with advantage to flank them.

Besides the arrangements already mentioned, intervals of from ten to twenty yards should be left between the shore and the works, for the troops to defile through; the interior is covered by a traverse in rear of the interval. A small defensive stoccade should be formed immediately at the head of each bridge, to enable a company of picked men to defend it until the bridge can be cast loose from the shore.

An interval of at least one hundred yards should be left between the bridges, if more than one is used, and about the same distance should be left between each bridge and the wings of the work.

There are no works that demand more care in their plan and construction than *têtes-de-pont* on important points. They should receive a strong profile so as to command all the approaches, and be thoroughly flanked, so as to render an open assault impracticable.

121. Villages. A village may play a very important part in an action, if suitable arrangements are made for placing it in a defensive attitude, to prevent the enemy from carrying it by storm. If the village is not too far in front of the line of battle, it should be strongly occupied; its rear being left open to receive succors. But if, by occupying the village, a very salient, and therefore a very weak point, would be presented to the enemy, then it would be best to demolish it, to prevent the enemy from taking advantage of it to cover his manœuvres whilst advancing, or from throwing a detachment into it to cover his retreat if repulsed.

To admit of a good defence, the houses of the village should be built of brick or stone, and not be too scattered. The enclosures of the gardens should consist of brick, stone, or mud walls, or a thick-set hedge. Wooden villages do not admit of a good defence, on account of the ease with which they may be burnt; but they should not on this account be abandoned to the enemy; for they offer a shelter, if only a temporary one, to troops, and by checking the enemy only for a short time, may render important service. Villages consisting of log-houses are the most defensible.

122. Military Posts. The term *military post* is applied to isolated positions, occupied by small detachments, for the purpose of guarding particular points which are of importance during the operations of a campaign, or for a longer or shorter period. These positions are frequently villages, farm-houses, etc.

The officer charged with placing a village in a defensive attitude, should first proceed to a careful examination of its environs, for the purpose of ascertaining what natural obstacles, and what facilities, they present to the approach of the enemy. Very slight accidents of ground may be greatly improved by trenches of trifling depth, with a profile similar to Fig. 64, to place troops speedily under cover. When the surface is undulating it should be particularly examined with this view, the officer taking a position at different points and directing men to approach him, and occasionally stooping to observe how much they will be masked from a fire at various heights above the surface. The side slope of a ridge from the enemy will be the best position for the trench to obtain speedy cover, provided the ground in advance of it can be well swept from its crest. The next points to be considered are the walls, hedges, etc., of enclosures, which may be turned to a useful account for the defence, or which might serve as a shelter to the enemy. After having finished this examination, he will next proceed to lay out his works; arranging their plan so as to draw every possible advantage from the natural and artificial obstacles at hand, to render certain points inaccessible, and to procure a shelter for his troops, and flanking arrangements by means of the walls, hedges, etc. If there should be danger of an attack before these works can be completed, the roads leading to the village, by which the enemy might approach, should be broken up; and cannon should be placed in the best position to guard the most accessible points. The streets of the village should be barricaded, and the houses and walls, in the vicinity of the barricades, should be placed in a defensive attitude. In taking these preparatory measures against a sudden attack, any means that will afford the troops a cover from the enemy's fire should be resorted to; bales of cotton or wool, casks set side by side, and filled with earth, piles of timber, etc., have been used with great success under such circumstances. As the various arrangements called for under such circumstances will demand great activity on the part of the garrison, care should be taken to distribute the work among the men most conversant with it, placing the men who have any skill in the handling of tools at preparing the wooden and stone defences, and common laborers at throwing up the earthen works, etc.

The works that surround the village should be placed so far from the houses that the troops shall not be incommoded either by the splinters occasioned by the enemy's artillery, or by the flames and smoke, should the houses be set on fire. The communications from all the exterior defences to some central rallying point should be carefully arranged, to avoid confusion in retreat, and check the pursuit of the enemy. The garrison should be made perfectly familiar with them, and with the resources they may afford, in case of need. Short-cuts should be made for this purpose by breaking through garden walls, the party walls of houses, etc., and by the erection of barricades at all suitable points to make a stand.

123. Hedges. A thin-set hedge cannot be placed in a good state of defence, and should therefore be destroyed, to prevent its interfering in any manner with the defence. At the best this defence will only serve as a screen, the hedge holding the earth up. A thick-set hedge (Fig. 69), if over six and a half feet high, should be cut down to this height, and the cuttings be set into the hedge to back the earth better; a small ditch is dug in front of the hedge, the earth from which serves to form a banquette and a slight parapet, which are thrown up against the hedge. If the hedge is less than six and a half feet high (Fig. 70), it is cut down to the height of four and a quarter feet; a ditch or trench, about three feet wide at bottom, and two feet deep, is dug behind the hedge, and the earth is thrown up against it, as in the last case. A width of two or three feet should be left between the trench and the earth thrown against the hedge to serve as a banquette.

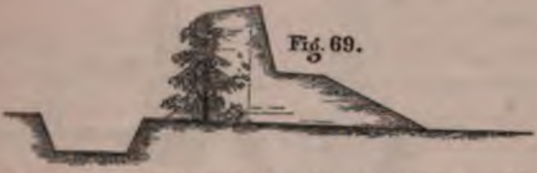


Fig. 69. Section of a Parapet behind a Hedge and a Ditch in front of it.

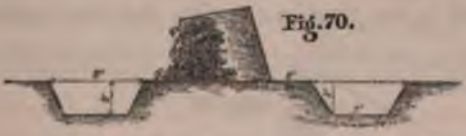


Fig. 70. Section of a Hedge Defence with Trench in rear.

A simple ditch behind a hedge will often serve as a good cover for light troops without any other preparation.

124. Walls. If a wall is of brick, or stone masonry, or of mud, and at least six and a half feet high (Fig. 71), it may be arranged for defence by cutting loop-holes through it, at three feet apart. For walls two feet thick, the interior width of the loopholes should be fifteen inches, the exterior width four inches, and the interior height twelve inches, and the exterior should be arranged to allow the fire to sweep as great a space as practicable.

The bottom of the loop-hole is four and a quarter feet above the ground. A small ditch, about three feet in depth, should be dug on the outside of the wall, and the earth thrown against it, to prevent the enemy from closing on the loop-holes.

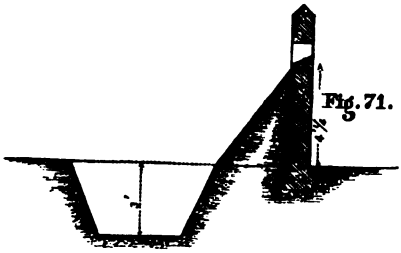


Fig. 71.

Fig. 71. Section of Wall over six and a half feet high with Ditch in front.

Where loop-holes have to be made through walls, it will not be practicable to preserve any uniformity of form or dimensions. The officer superintending their arrangement should see that they afford a clear view and thorough sweep over the approaches of the assailed.

If the wall is less than six and a half feet high (Fig. 72), it should be cut down to the height of four and a quarter feet; or else a banquette should be made against it. A trench is dug behind it, as in the case of a hedge of the same height; a ditch of about two feet deep should be dug in front of the wall, to prevent the enemy from reaching the assailed with the bayonet, and to place an obstacle to his climbing over the wall.

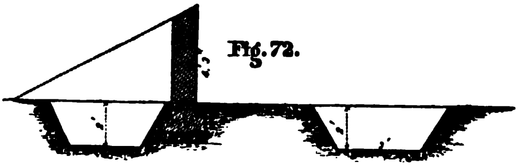


Fig. 72.

Fig. 72. Section of a Low Wall with Trench in rear and Ditch in front.

Walls which are eight feet high (Fig. 73), may be arranged with a double tier of fire; for this purpose a banquette of boards, sustained by *trestles*, or by casks, is made, to enable the assailed to fire over the wall; loop-holes are made near the foot of the wall, and a ditch is dug behind it, to obtain a second tier of fire.

In this case no ditch should be made on the outside of the wall, because it might enable the enemy to close on the loop-holes.

If a long line of wall should require flanking arrangements (Fig. 74), a timber work, termed a *tambour*, is made on the outside; this work is made like a defensive stoccade, with square or round timber about six or eight inches in thickness; the plan of the tambour is that of a redan, or lunette with a salient angle of 60°. A hole is made through the wall to communicate with the tambour, and loop-holes are made in the wall to flank the faces of the tambour.

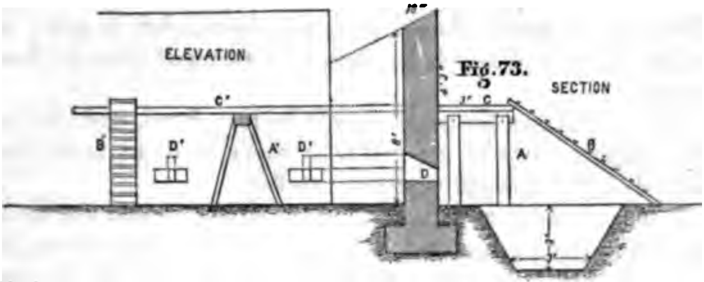


Fig. 73. Section and Interior Elevation of a Wall for two tiers of fire. A, A', Trestle support of Platform C, C'; B, B', Gang Plank; D, D', Loop-hole.

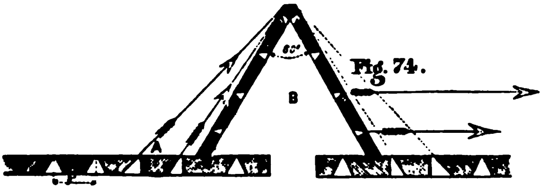


Fig. 74. Plan of Wall A flanked by Tambour B.

125. Barricades. Wagons, or carts, sunk in the ground up to their axle-trees, and loaded with stones, or earth, will form a very good barricade. A pile of loose stones will serve the same purpose in some cases; also timber laid in piles, lengthwise and crosswise, with the open spaces filled with stones, or earth, forms an excellent barricade. A ditch in front adds to the obstacle.

Barricades should be defended from behind with musketry, and cannon loaded with case shot; a work, like a defensive stoccade, will therefore be the best arrangement for them.

126. Houses. To place a house in a defensive attitude, the doors and windows of the lowest story should be firmly barricaded, and loop-holes be made as in the case of a wall. A tambour should be placed before the doors, both for their protection and to procure flanking arrangements if required. The windows of the upper stories should be partly barricaded, to cover the troops within, and loop-holes should be arranged as in the lower stories.

The roof, if not fire-proof, should be torn down, and the floor of the upper story be covered with earth or dung, moist from the stable, to the depth of about two feet.

If it is intended to defend the upper stories, should the enemy succeed in forcing the lower, the stairs should be torn down, and slight ladders be used in their stead; holes should be made through the floor to fire on the enemy in the lower story, or to throw heavy articles, or boiling water, etc., on him.

If there are balconies to the windows of the upper stories, or an upper gallery, they can readily be placed in a defensive state by placing thick boards as a shelter on the outside, and cutting holes through the floor to defend the doors and windows of the lower story.

If there are no conveniences of this nature, a temporary structure, termed a *machicoulis gallery* (Fig. 75), may be formed, by placing stout pieces of scantling through holes made in the wall, on a level with the floor; these pieces being confined to the floor on the inside, either by nailing them to it or by tying them with rope to the joists; they should project from three to four feet

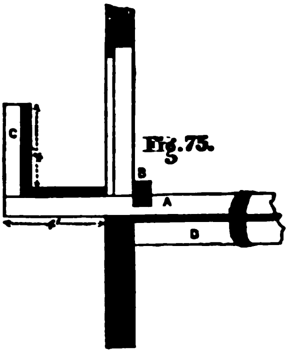


Fig. 75.

Fig. 75. Section of a Machicoulis, D, Flooring Joists; A, Horizontal Supports; B, Cross Timber; C, Uprights of front.

beyond the wall on the exterior, and vertical pieces of smaller scantling, about four feet long, should be nailed to them, on which boards are nailed to cover the troops from the enemy's fire; these boards should be at least three inches thick. The flooring of the gallery is laid on the horizontal pieces, and holes are made through it to fire on the enemy, or to throw grenades, stones, etc., on him.

Any similar arrangement which will shelter a man, in the act of firing from a window on the foot of the wall, or in throwing over stones, etc., will serve the same purpose as a machicoulis gallery. A table might easily be arranged to answer the end in view.

In arranging a house for defence, everything should be turned to account. The chimneys may be partly torn down on the interior to obtain bricks to barricade the windows. The flooring boards may be used for the same purpose, and pillow cases filled with earth, blankets, books, etc., be thrust in between the boards nailed on the inside and outside of the windows. By tearing away some of the partitions, and taking up some of the joists of floors, heavy timber may be procured for the machicoulis galleries, for buttresses, for the lower barricades, for shores, etc.

The intelligence of the officer will readily suggest to him the uses to which the objects at hand may be applied.

Rough timber, such as logs and fence rails, make excellent impromptu defences in the open field. A few rails piled on each other, in the same way that they are laid in a worm fence, will alone give shelter to a man lying down in the angle they form; and if, in addition to this, a shallow hole can be dug, and the earth from it thrown up against the rails, a very good mask will be obtained for a sharpshooter.

When there is time for it, a breastwork can be formed of logs laid upon each other, by using tie-pieces which are notched, on the two opposite sides, to fit into corresponding notches made in the lower and upper logs, which are thus connected in this rough way. The ends of the tie-pieces may project a foot towards the inside for mounting the top of the parapet, and two or three feet on the outside, where they are covered with the earth of the parapet. In like manner, by using short pieces notched on each side, so as to leave space enough between the top log of the parapet and another log laid above it, upon the short notched pieces, for a man to fire through, good shelter will be obtained for a man's head whilst in the act of firing.

Logs may be used in this way instead of fascines, etc., for revetting the interior slope; or else they may be cut into short lengths, halved, and laid side by side, bark side out, inclined so as to hold up the earth of the parapet. More damage, however, will be done by artillery against a revetment of this kind, than against those already described, and most generally employed.

CHAPTER X.

SEMI-PERMANENT FIELD WORKS.

127. General Considerations. The capabilities of field works, when properly planned and built and strongly defended, to resist the most vigorous open assaults, and to force an assailant to the slow and less bloody operation of gaining possession of them by the means used for reducing permanent works, which are perfectly secure from any other mode of attack, are facts of long standing, illustrated by military history. They are the more important to ourselves as this is the only defensive system of fortification that we shall, for a long period at least, be able to use for the security of our large cities from attacks on land.

The system which engineers seem now in favor of, and which, from the great space covered by our cities and the immense development of lines which would be called for to secure them from the long ranges of rifled cannon, is alone practicable, is that of a series of works, either enclosed with a parapet, or with open gorges, occupying the most commanding positions of the defensive zone, and at least in reciprocal flanking range of artillery of each other, and which are connected by lines of a smaller relief, and so adapted to the ground as to sweep all the approaches, and afford good flanking arrangements of the lines themselves.

128. Character of Works. The detached works should not only receive a strong profile, but have accumulated in their front every accessory obstruction that will best impede the assailant in an attempt at an open assault, and if not flanked from the parapet be provided with secure ditch defences. The arrangement for the armament should be of the most substantial character for heavy guns and mortars. Bomb and splinter-proof shelters should be provided for the security and lodging of the garrison, and in works open at the gorge, these should be placed across the gorge and be loop-holed to meet an assault in the rear.

129. Exterior Defences. If the ground in advance of these works is not well swept by their fire, or that of the connecting intrenchments, the ordinary trench (Fig. 75, bis), now better known as rifle-pits, should be made for this service. Besides these, good covered communications for field guns should be arranged so that batteries may be speedily moved from point to point, where their services may be most needed. These covered ways should also be arranged for the use of musketry (Fig. 76).

Fig. 75.

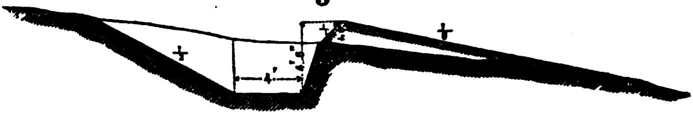


Fig. 75 bis. Section of Trench or Rifle-Pit.

Fig. 76.

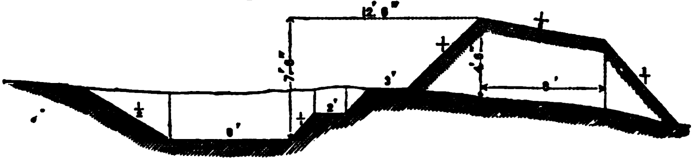


Fig. 76. Section of Covered Trench and Parapet for the circulation of artillery and for musketry defence.

The plan of these works will depend upon the character of their site and the more or less exposed position of it to the fire of the assailant. For the most important, bastioned forts (Fig. 77) will be the best; for others the star fort, redoubt; or simply lunettes, or redans will suffice. No specific rules can be laid down, as everything must depend on the judgment and skill of the engineer charged with planning the defences.

130. General and Detailed Plans. In the exercise of this judgment the engineer will be called upon to make a particular study of and draw up memoranda on the general plan of defence for the whole position to be occupied, in which he will have to consider its extent and its topographical and military features; the side towards which it must be particularly fortified; the defensive and offensive character of the fortifications best adapted to it; its most striking tactical points both absolutely and relatively to the general plan of defence; the number of troops by which it is to be occupied; and the time in which, with the means at his disposal, the fortifications can be erected. These general points having been settled, the next step will be to consider the most suitable kind of work for each point, taking into account all natural and artificial obstructions that will contribute to the defence, the tactical relations of each work to the others, and the best distribution of the troops for each one. The discussion of the peculiar features of each work as to its profile, defilement, and construction, will finally be fixed in accordance with the natural and artificial features of the site exterior to the works; the nature of the ground itself; and the disposable means that the locality itself may furnish for the construction of the work.

All of this demands, on the part of the engineer, a thorough knowledge of general principles and an acquaintance with all the details and resources of his art.

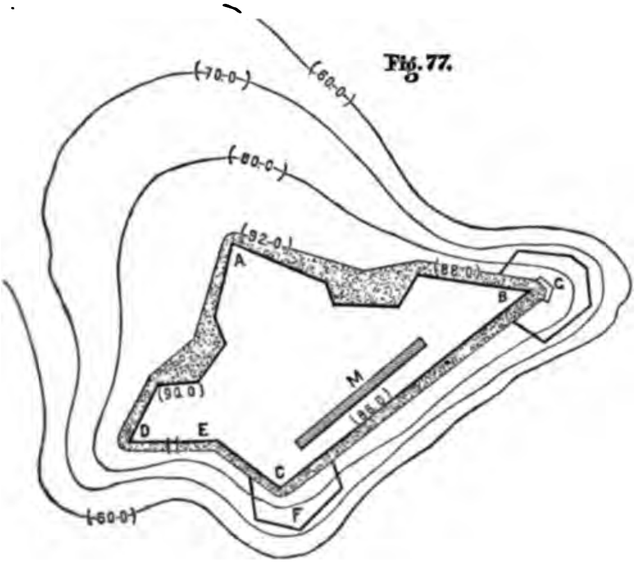


Fig. 77.

Fig. 77. Represents the topography of the Site, and the General Plan of a Fort for its immediate defence, and in reciprocal defensive relations with other works on its flanks. The fronts A B and A D are bastioned, and so placed that the fire from their faces and curtains, armed with heavy guns, can sweep the approaches on the collateral works; their flanks, armed with guns of smaller range, sweeping the principal approach to the work and flanking the ditches of the Sallent A. The front D C, to suit the configuration of the ground is tenailled, and the one B C, for the same reason, is simply a right line, with only sufficient relief to sweep the approaches in front and be secure from a fire of musketry.

For the better flanking of the ditch of the face at the salient B, and the front B C, a counterscarp gallery is placed in front of B.

Rifle-pits are arranged at F and G to sweep the steep ground in advance of the fronts A B, B C, and C D.

As the site admitted of some discretion in fixing the salient A, and the direction of the two fronts A B and A D, these are supposed to have been so determined as to avoid all enfilading and reverse views on these two fronts.

The command of these two fronts from A, each way to the opposite flanks, is supposed to be so regulated as to sweep the approaches on the two fronts and to cover all the interior from plunging fire.

The outlet is at F, and a bridge leads from it across the ditch to the road which passes around the salient D, along the ridge in front of A.

M represents the bomb-proof barrack, covered in front by the parapet and arranged as a keep.

CHAPTER XI.

DEFILEMENT OF LINES AND FIELD WORKS.

131. General Considerations. Where the site of a work is sensibly horizontal, and there are no commanding points within cannon range from which an assailant can get such a view into it as to regulate his fire with some certainty, there is no controlling motive for making the relief other than uniform; though it lessens, to some extent, the effects of an enfilading fire, by making a face higher at the salient, giving it a uniform slope back, as the higher the covering mass over which the fire of the assailant must pass to reach the interior of a work, the greater will be the portion of the work screened. The extent of the cover thus gained will depend upon the angle of elevation and the charges with which the assailant's fire is maintained. With great angles and heavy charges from considerable distances, and great angles and light charges when near to the work, the projectile may receive a great plunge in the descending branch of its trajectory, so as to fall quite close behind the covering object; but these great plunges are unfavorable to ricochet, so that if the assailant wishes to preserve this fire, which is generally regarded as the most effective in enfilading the interior of a parapet, he must sacrifice the effect of great plunges, and submit to the advantage of better cover which the assailed gains by raising his salients, or using traverses for the same end.

132. Defilement. When the site is not horizontal and there are commanding heights from which the interior of the work can be plunged into, by firing under small angles of depression, or ground lower than the work from which a reverse fire can be obtained, on the more elevated portions, over the parapet of the lower portions, the parts thus exposed must be screened either by raising the parapet to a suitable height, or by interposing a covering mass within the work for the same object.

The operation by which this is effected is termed *defilement*, and when a work is thus screened it is said to be *defiled*.

133. Defilement of Lines. Defilement is seldom practicable, nor in fact is it necessary for lines of any considerable extent. The most that can be attempted is so to vary the plan, when it can be done and not impair the efficiency of the fire of the different parts on the approaches, as to prevent the prolongation of any important face or flank from falling on any point where the assailed would have a commanding position to enfilade; rather giving those parts a direction such that their prolongation outwards shall fall on low ground, or on points inaccessible to the artillery of the assailed. No specific rules can be laid down further than of a general character. Taking, for example, a line of works to be thrown up within cannon shot of a range of heights, the crests of which lie in the same direction and are sensibly horizontal, the best cover that could be obtained in this case would be a simple right line of uniform relief, the direction of which should be parallel to that of the crests. If the site on which the line is placed is horizontal (Fig. 78), by giving a good height to the parapet a sheltered zone for the troops and *matériel* of more or less extent will in this way be obtained. If the site, as at E, slopes (Fig. 78) from the range of heights, then the same height of parapet will mask a broader zone of shelter, and the more so as the declivity of the surface is the more decided. But if the site slopes towards the crests, as at D (Fig. 78), the difficulty of obtaining shelter will be the greater as this counterslope is the greater.

Fig. 78.

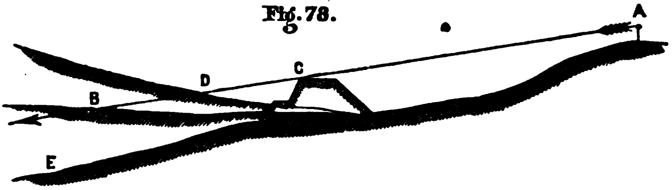


Fig. 78. Section of Site showing the Cover given from enemy at A, by the Parapet C, as the ground as at B is level, or at D rises, or at E falls away behind the Parapet.

If instead of a right line a broken line is used, as a redan, or a serrated line, then it will be well to make the face of each redan or tenaille (Fig. 79), as short as practicable, and to make the salient angles very obtuse. In this manner but short lines will be presented to an enfilading fire, and the prolongations of these lines be brought to intersect the crest of the range at more distant points, thus forcing the assailant to use higher angles of elevation to reach them from his enfilading position.

Fig. 79.

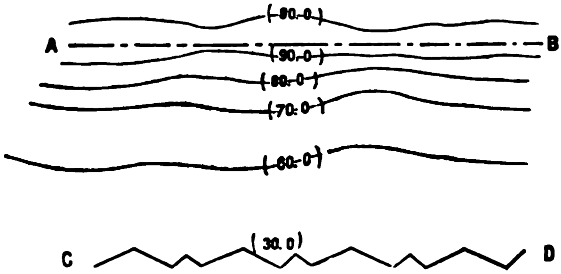


Fig. 79. Plan of Lines C D, thrown up Parallel to Crests A B. The numbers giving the References of the ground and line.

When the line of the crests descends in a right line towards the site (Fig. 80), then supposing the general direction of the

Fig. 80.

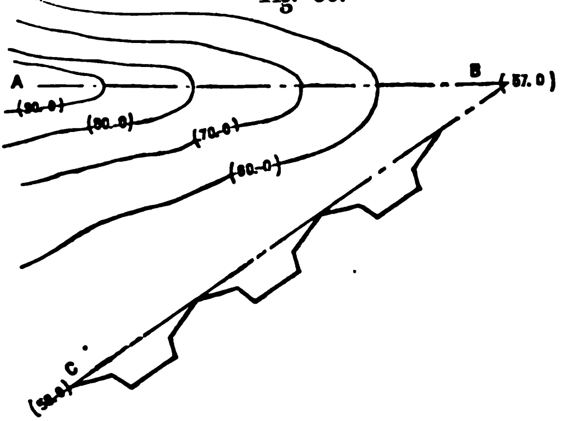


Fig. 80. Plan of Site and Line C D in front of a Crest A B, descending uniformly to about the same level as the Line. The numbers give the references of the ground and Line.

parapet to be a right line, the most favorable position for the defilement, by a uniform relief given to the line, will be to give the line of the parapet a direction upon the point where the line of the crests prolonged would meet the site. The zone of shelter covered by the parapet in this case, will be so much the greater, and the defilement the better as the general direction of the parapet makes a greater angle with that of the crest. The same remarks apply to a sloping or counter-sloping site.

As the position of the works become the less restricted, there will be freer play for the skill and eye of the engineer to obtain a good solution of the question.

134. Defilement of Field Works. For works open at the gorge and enclosed works, defilement becomes more important as the force being small every means should be employed for its safety. In such works there is also much less freedom to vary the plans. The most that can be done is to avoid enfilading or reverse views, by opening more or less the salient angles so as to bring the more prominent dangerous points within the angle of the adjacent faces prolonged, or to bring those prolongations upon dangerous points as distant as practicable. In the first case a reverse fire on either face will be avoided, and in the second the enfilading position of the assailant will be thrown to a further distance.

The *defilement* of field works is not indispensable to a good defence; nor is it always practicable. It is, however, not only a conservative means, but it also inspires the assailed with confidence; for the soldier regards with distrust the strength of his position, when he finds himself exposed to the view of the enemy from an elevated point.

135. Practical Direct Defilement. The defilement of a work is a practical operation performed on the ground in the following manner:

Let A B C D E (Fig. 81) be the plan of a work, a lunette for example; and the points O, O, etc., lying within the angle formed by the prolonged direction of the two faces B C, D C, the most elevated points of a commanding position in front of the work. At the points A, B, etc., let straight poles be planted vertically, and on the poles along the gorge line let a point be marked, at three feet above the ground. Let two pickets be driven in the ground along the gorge line, and a cord A, B, or a straight edge of pine, be fastened to them, on the same level as the two points marked on the poles at A and E. Let an observer now place himself in the rear of A B, so as to bring the poles at B, C, and D, and the points O, O, etc., within the same field of vision. Let observers be placed at B, C, and D. The first observer now sights along A B, until he brings his eye in the position that A B will appear tangent to the most elevated of the points O. Having accurately determined this position, he next directs the other observers to slide their hands along the poles until they are brought into the same plane of vision with the point O, and the line A B, and to mark those points on the poles. These points, together with the two first marked, will evidently be in the same

Fig. 81.

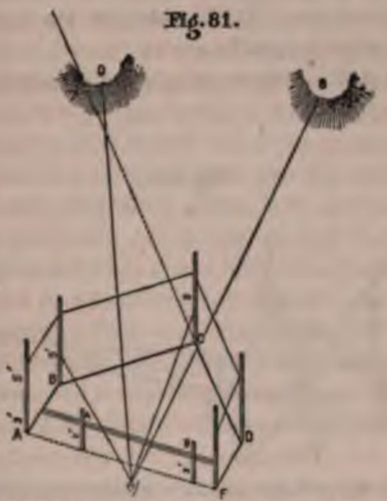


Fig. 81. Plan of Work A B C D E, showing the manner of Defiling it from the Heights O O, lying in front of its faces.

plane, and this plane, produced, will be tangent to the highest point O. It is denominated the *Rampant Plane.* Now if a point be marked on each pole, at five feet above the points thus determined, these points will be contained in a second ideal plane, parallel to the first, and five feet above it. This plane is denominated the *Plane of Defilement,* and the interior crests of the work are contained in this plane, being the lines joining the highest points marked on the poles.

As the gorge line is farthest from the heights, and the rampant plane ascends towards them, it will necessarily pass at more than three feet above every other point of the parade of the work; and the plane of defilement, in like manner, will pass at eight feet above the parade at the gorge, and at five feet above the highest point O. A plane of front defilement is therefore defined to be, *that plane which, containing the interior crests of a work, passes at least eight feet above every point of the parade, and at least* *five feet above every point that the enemy can occupy within the range of cannon.*

136. Practical Reverse Defilement. When a work is placed in a hollow formed by two eminences, and is exposed to both a direct and reverse fire from them, it cannot be defiled by the means just explained, without giving it a relief generally too great for field works. To avoid this the method of reverse defilement must be resorted to.

Let A B C D E (Fig. 82) be the plan of a lunette, placed between the two eminences O, O′; its face and flank A B C being exposed to the direct fire from O, and a reverse fire from O′; the other face and flank being in like manner exposed to a direct and a reverse fire.

Fig. 82.

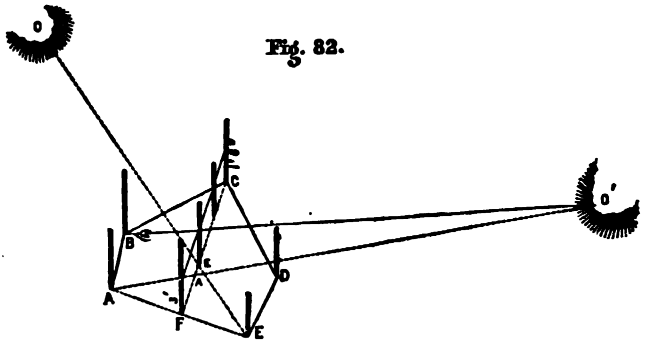


Fig. 82. Plan of Work A B C D E to be defiled from the Heights O, O′.

Suppose the work defiled, and a section (Fig. 83) be made by vertical planes passing through the highest points O and O′.

Fig. 83.

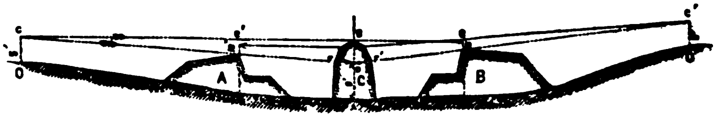


Fig. 83. Section of Parapets A, B, and Traverse C to cover from fire from O, O′.

If in this plane a vertical, A B, be drawn, corresponding to the capital of the work, and eight feet be set off on this vertical from the point A, and two verticals be drawn through the points O and O′, and five feet be set off on each of them; and then the points

C and C′ be joined with D, it is obvious that the interior crest of the parapet A, being placed on the line C D, will screen all the ground in the rear of it, as far as the capital, from the direct fire from O. The parapet B being regulated in a similar manner, will screen all the ground behind it as far as the same line. But the fire from O′ would take the parapet A in reverse, and that from O the parapet B; to prevent this, a *traverse* must be erected on the line of the capital, and a sufficient height be given to it to screen both A and B from a reverse fire. To effect this, let eighteen inches be set off above the interior crests of A and B; the point E being joined with C′, and the point E′ with C; it is here also obvious, that if the top of the traverse be placed on the line C E′, it will effectually screen both the parapets from all reverse fire; because every shot that strikes the top of it will pass at least eighteen inches above the two parapets, and, since the banquettes are four feet three inches below the interior crests, the shot must pass five feet nine inches above the banquettes, which will be quite sufficient to clear the heads of the men when on the banquettes. This illustration explains the spirit of the method of reverse defilement. The operation itself is performed in the following manner:

Poles (Fig. 82) are planted at the points A B C, etc., and one at the point F, where the lines of the capital and gorge intersect. On the pole F, a point is marked three feet above the ground, and a point is likewise marked on the pole at C, which should be one foot six inches higher than that on F; that is, if the ground between the two poles be level, the point on C will be four feet six inches above the ground. This is done to place the salient higher than any other point and to give the faces a slope unfavorable to enfilade. Two stout pickets may next be planted between F and C, and a cord, or a straight edge, be fastened to them, so as to be in the same line as the points marked on the poles.

Observers are then placed at the poles A and B; and another places himself behind the cord so as to bring the poles O, A, and B, in the field of vision with it; then shifting the position of the eye until the cord is brought tangent to the highest point on O, he directs the observers at A and B, to mark on the respective poles the points where the plane of vision intersects them. This operation will determine the rampant plane for one-half the work

A B C F, that for the other half will be determined by a similar process. If then a distance of five feet be set off on each pole above the points thus determined, these points will fix the position of the interior crests.

It is obvious that the interior crest of the part A B C is not in the same plane as that of the part C D E. These two planes are denominated *planes of direct defilement.*

To determine the height of the traverse is the next step. To do this, the height of the tread of the banquette is ascertained on the three poles, B, C, D, and a distance of nine inches is set off on each pole above the tread. This is done for uniformity of position of the rampant and defilement plane. Between the points thus determined a cord is stretched, or if the distance be too great for this, two pickets may be placed between B and C, and a cord, or straight edge, be fastened to them in the required direction. An observer is then placed at the pole F, and another places himself behind the line B C, so as to bring the cord, and the points O′ and F, in the field of vision; he then shifts the position of the eye until the cord is brought to touch the point O′; he then directs the observer at F to mark the point on the pole where it is intersected by the plane of vision. A similar operation is performed with the point O, and the face C D, and above the highest point thus determined on F, a distance of five feet is set off for the top of the traverse at F; and five feet nine inches is set off above the tread of the banquette at C for the top of the traverse at that point.

The planes which determine the top of the traverse, are termed *planes of reverse defilement.*

The traverse is finished on top like the roof of a house, with a slight pitch; its thickness at top should seldom exceed ten feet, and will be regulated by the means the enemy can bring to the attack; its sides are made with the natural slope of the earth; but, when the height of the traverse is considerable, the base of the side slopes would occupy a large portion of the interior space; to remedy this, in some measure, the portion of the sides which are below the planes of direct defilement, may be made steeper than the natural slope; the earth being retained by a facing of sods, etc.

When the salient of the work is arranged for defence, the traverse cannot be extended to the salient angle; it is usual to change its direction within some yards of the salient, and unite it with the face most exposed. Traverses are also used to cover faces exposed to an enfilade fire; for this purpose they are placed perpendicular to the face to be covered. If several are required, they may be placed twenty or thirty yards apart; each traverse should be about twenty-four feet long, and thick enough to be cannon proof.

As the traverses require a large quantity of earth, and much time and labor for their construction, their length should not be greater than is indispensably requisite to form a good screen. This may be determined by drawing lines from the dangerous points to the furthest point of the line to be screened; the one which intersects the line of the traverse furthest from the salient will give the best length of the required traverse. The lines drawn from O and O′ to E and A, cut the line of the traverse at A and C, thus requiring the traverse to be run back to *a* to cover each face and flank.

The difficulty of defilement, owing to the great relief that may be required for the parapets, the labor of erecting the traverses, and the room which they occupy within the work, which is frequently wanted for the defence, restricts its application mostly to enclosed works, which are to remain occupied during some time, and whose position, from some point to be defended, cannot be shifted.

The position of a work on inclined ground, where one face is on higher ground than the other, may equally expose the higher face to reverse views from the ground lower than the lower face, as in Fig. 83 bis, for example, where a traverse C would be necessary both to cover the parapet A from the plunging fire from c and the parapet B from the reverse fire from c.

Fig. 83. bis.

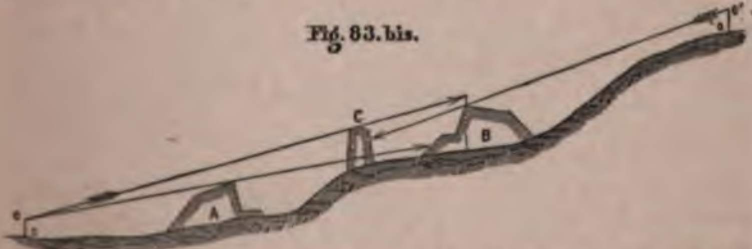


Fig. 83 bis. Section of Parapets A, B, covered by the Traverse C from reverse fires from c and c′.

The cases of defilement here examined, are those of works open at the gorge; the same principles, and similar methods, would be applied to enclosed works. After the plan of the work has been regulated, the arrangement of the traverses next demands the attention; the only rule that can be laid down is, to place them in the most favorable position to intercept the reverse and enfilading fire of the enemy; and if there should be a choice with respect to several positions, to select the one which will give the lowest traverse.

If it is not even probable that a commanding eminence will be occupied by the enemy, nevertheless should the defence be not impaired, it will be better to place the work beyond the cannon range of the eminence.

137. Ditch of Defiled Works. The irregularity in the profile of the parapet, caused by defilement, will occasion a correspondent irregularity in that of the ditch. Where the parapet is highest, the ditch will require to be widest and deepest; for, in order to avoid the removal of the earth to considerable distances, it is best that the earth for each portion of the parapet should be taken from the ditch in front of it. No other rule can be laid down in this case, than to keep the dimensions of the ditch within the prescribed limits; and, if this will not admit of its counterscarp being well defended, to raise a glacis in front of it, subject to the fire of the work.

CHAPTER XII.

ATTACK AND DEFENCE OF TEMPORARY FORTIFICATIONS.

138. Attack. The subject of the attack admits of two natural divisions; the first of which comprehends all the preliminary steps taken before the troops are brought into action; the second all the subsequent operations of the troops.

An attack is made either by *surprise*, or *openly*. In both cases exact information should be obtained of the approaches to the works; their strength; the number and character of the garrison; and also the character of the commander. This information may be obtained through spies, deserters, prisoners, and others who have access to the works; but implicit faith ought not to be placed in the relations of such persons, as they may be in the interests of the garrison; and in all cases they should be strictly cross-examined and their different representations be carefully compared with each other.

The best source of information is an examination, or *reconnaissance*, made by one or more intelligent officers. This reconnaissance should, if possible, be made secretly; but as this will not be practicable if the garrison show even ordinary vigilance, it will be necessary to protect the reconnoitring officer by small detachments, who drive in the outposts of the garrison. The object to be attained by the reconnaissance is an accurate knowledge of the natural features of the ground exterior to the works; the obstacles it presents, and the shelters it affords to troops advancing; the obstacles in front of the counterscarp and in the ditches; the weak and strong points of the works, and the interior arrangements for the defence. If the work is an isolated post, information should be obtained as to the probability of its being succored in case of an attack; the length of time it must hold out to receive succor; and the means it possesses of holding out.

139. Attack by Surprise. A surprise is an *unexpected attack*, for which the assailed are not prepared. It is, perhaps, the best method of assailing an undisciplined and careless garrison, for its suddenness will disconcert and cause irremediable confusion.

Secresy is the soul of an enterprise of this nature. To ensure it, the garrison, if aware of the presence of the troops, should be deceived and lulled into security by false manœuvres. The troops that form the expedition should be kept in profound ignorance of its object until they are all assembled at the point from which they are to proceed to the attack.

The winter season is the most favorable for a surprise, which should be made about two hours before day, as this is the moment when the sentries are generally least vigilant, and the garrison is in profound sleep; and the attempt, if at first successful, will be facilitated by the approach of day, and if unsuccessful, the troops can withdraw with safety under the obscurity of night. Should there be danger, from succors arriving in a short time, the attack should be made soon after midnight, when the garrison is asleep, so that the troops may retire before daylight, after having attained their object.

As a general rule, the troops for the attack should consist of a storming party, divided into an advanced party and its support, and be followed by a reserve of picked men. The advance of the storming party will open the way, and be closely followed by the support in the assault of the parapet, and a reserve of picked men. There should be two guides, one in front of the storming party, with the detachment of workmen under the command of an engineer officer; the other in the rear, under charge of a guard, to supply the place of the first, if killed. The workmen should be furnished with axes, crow-bars, pick-axes, etc., and several bags of powder, of about thirty pounds each, to be attached to palisadings, fraises, and barriers, to blow them down, if the alarm should be given whilst they are opening a way through them by other means. All the operations should be carried on with dispatch and in silence. Should the sentries challenge, they must be secured or bayoneted.

Circumstances alone can determine whether it will be advisable to make false attacks with the true one. They will distract the attention of the garrison, if the alarm is given, from the true attack; and a false attack has sometimes succeeded when the true one has failed. When made, one should be directed against the strongest point of the work, as the strong points are usually guarded with less vigilance than the others; and they should all be made at some distance from the true attack; and orders be given to the detachments making them to proceed to the point of the true attack, should they succeed in making their way into the work.

If the attack succeed, immediate measures should be taken to place the works in a state of defence, if the position is to be maintained; or else they should be destroyed, as far as practicable, before retreating from them.

140. Attack by Open Force. The general arrangements for an open assault, comprehend the operations to gain possession of the works; the measures for maintaining possession of them, and following up the first advantage; and, finally, the precautions to be observed in the event of a repulse.

An open assault may be made either with the bayonet alone, or with the combined action of artillery and the bayonet. The first is the most expeditious method, but it is attended with great destruction of life; it should therefore only be resorted to against works of a weak character, which are feebly guarded; or against isolated posts within reach of speedy succor. When tried it will usually be best to make the attack just before day. If it is made by daylight it will, in most cases, be well to scour the environs with a few squadrons of cavalry, to pick up patroles and stragglers who might give the alarm, and then push forward rapidly the assaulting columns. If the assailed seem prepared, light troops should precede the columns of attack, with orders to display in front of the counterscarp, and open a brisk fire on the assailed, for the purpose of diverting their attention from the columns of attack.

In an attack with artillery, the troops are drawn up in a sheltered position, or beyond the range of the guns of the assailed; batteries are then established within twelve to six hundred yards of the works, in the most favorable positions to enfilade the faces, and destroy all visible obstacles. The batteries keep up an incessant fire of ball and hollow projectiles, in order to dismount the cannon, and create confusion among the assailed. When the fire of the works is silenced, the troops are thrown forward, and demonstrations are made on several points, to divert the attention of the assailed from the true point of attack, and prevent him from concentrating his strength on that point. Several false attacks should be made at the same moment with the real one, and each of them should be sufficiently formidable, in point of numbers, to enable the troops to profit by any success they may obtain.

The number and disposition of the troops making the assault will depend, in so great a degree, on local circumstances, and the arrangements of the assailed, that nothing more can be laid down under this head than some general rules.

The attack should be led by a storming party, composed of picked troops, or of volunteers for the occasion; this party is preceded by a detachment of engineer troops, provided with the necessary means to make their way through all obstacles, to enable the storming party to assault with the bayonet. If the detachment is arrested at the crest of the counterscarp, by obstacles which must be destroyed before farther progress can be made, the leading files of the storming party may open a fire on the assailed to divert their fire from the workmen; but this operation should only be resorted to from necessity, as it breaks in on that unity so essential in an operation of this character, and impairs the confidence of the soldier in the bayonet, on which his sole reliance, in such cases, should be placed.

The storming party should be provided with light scaling ladders, planks, fascines, strong hurdles, etc., for the purpose of descending into the ditch; to mount the scarp; to cover trous-de-loup, small pickets, etc., etc.

Another detachment of engineer troops follows in the rear of the storming party; its duties consist in rendering the passages, opened by the first detachment, more accessible to the troops, who immediately follow it to sustain the storming party. This second detachment is also charged with the care of placing the work from which the assailed has been driven in a defensive attitude, in order to frustrate his attempt to repossess himself of it. The first detachment should be charged with this duty: for, independently of having handsomely acquitted itself in bearing the brunt of the action, it may be required to precede the storming party in the pursuit of the assailed to his interior works.

The troops destined to support and, if necessary, reinforce the storming party, advance in one or two lines, with cavalry, and some pieces of artillery on the wings, to repel sorties. The remainder of the troops follow in order of battle, to improve the first successes, or to cover the retreat of the assaulting columns, if repulsed.

The salients are generally the points on which the storming party advances, unless some natural feature of the ground should present greater facilities for advancing on a reëntering, or in front of a face. When the ditch is gained, shelter is sought in a dead angle; and if the work is fraised, or resolutely defended with the bayonet, a breach must be made, either by firing beforehand hollow loaded projectiles into the parapet, or by undermining the scarp with the pick. If the intrenchments consist of detached lunettes, an attack should be made on their gorge at the same moment with the one in front.

When the assailed are driven from their main works, the storming party should press hotly on their rear, and endeavor to enter pell-mell with them into their interior works, leaving to the troops which follow them the care of retaining possession of the works gained; but, if the intrenchments are supported by other troops drawn up in order of battle, the storming party should halt in the works until it is reinforced by the troops in its rear.

There is no danger to be apprehended, in case of a retreat, after an unsuccessful attack on an isolated work. But in an attack on intrenchments, supported by an army, the retreat of the storming party should be covered by cavalry and artillery, until it can find safety behind the main body of the troops, drawn up in order of battle to protect it, and to receive the assault of the assailed, should he attempt offensive operations.

In conducting the attack, preparations should be made beforehand for removing all the artificial obstacles that the assailed may have placed before their works, to impede the progress of the storming party. This duty is usually intrusted to the detachment of engineer troops, who are provided with axes, picks, and other suitable tools for this purpose. When the obstacles are of a nature to be easily destroyed by artillery, it should always be resorted to. Abattis, palisades, fraises, and entanglements, when exposed, may be readily torn to pieces by opening an enfilading ricochet fire on them. When cannon cannot be brought to bear on these obstacles, an abattis may sometimes be set fire to, and palisades, etc., be blown in by attaching bags of powder to them. Trous-de-loup may be passed, either by covering them with plank or strong hurdles, or else by directing the men to pass cautiously between them in extended order; small pickets may be broken down, or else fascines may be spread over them so as to form a tolerably stable road-way; fascines may also be used to cover the points of spikes.

The passage of the ditch, and the assault of the parapet, are the most difficult operations. If the ditch is not more than six feet deep, it can be leapt into without danger, and the men can mount the scarp readily with a very little assistance from each other. When the width is not greater than twelve feet, the ditch may be crossed by laying thick plank, or small scantling, over it. When the depth is over six feet, the storming party is usually provided, either with small scaling ladders for descending into, or with fascines, sand-bags, or other means, to fill the ditch partly up; or if these means cannot be procured, the detachment dig away the counterscarp into steps, throwing the earth into the ditch, and thus, in a short time, form an easy entrance to it. Wet ditches may be filled up either with sand-bags alone, or more expeditiously by attaching sand-bags to large fascines, or to trusses of hay or straw.

The assault of the parapet is made by the aid of scaling ladders, or by effecting a breach, by firing loaded hollow projectiles into the scarp and parapet, which, by their explosion, crumble the earth down, so as to form an accessible ramp; or else the foot of the scarp is undermined with the pick, and the mass of the parapet tumbled into the ditch.

141. Defence. The essential point in the defence is to have every part of the works guarded by a sufficient number of troops to resist an attack on all sides. This is of importance not only in isolated works, which can be surrounded, but also in continued lines; for although the enemy will usually make an attempt to enter only at a few points, still the confusion and delay which might arise from changing the position of the troops, to meet the movements of the enemy, particularly in a night attack, would be extremely hazardous.

A vigorous defence will require, at least, two ranks to be drawn up on the banquette throughout the entire extent of the line, with supports, and a reserve proportioned to the importance of the work.

The strictest vigilance should be exerted to guard against a surprise; for this purpose sentries should be posted on all of the most commanding points of the works; and on the exterior, at such points as the enemy might approach unseen, as roads, fords, defiles, bridges, etc.; besides these, small detachments of picked men should be stationed to watch these accessible points, and all other places where the enemy might secrete himself, or approach unexposed to the fire of the works. Patroles should be sent out to watch the enemy's movements, and to have an eye on the manner in which the sentries perform their duties. The patroles are particularly charged with the duty of preventing the enemy from reconnoitring the approaches to the works; to do which effectually, without giving unnecessary alarms, they should be ordered to attack with the bayonet alone, unless surprised by an ambuscade.

At night the number of sentries should be increased; and redoubled vigilance be used, particularly after midnight. If there are well grounded apprehensions of an attack, *fire-balls* may be thrown out, or fires be lighted in front of the works, to discover the approach of the enemy. Occasional false alarms should be made to keep the garrison on the alert; but this artifice should not be too often practised, otherwise it might produce a contrary effect; besides, all useless fatigue should be spared men who are sufficiently harassed by the ordinary duties of their situation.

In conducting the defence, each corps should have its particular post assigned to it; and receive special instructions relative to the part it will have to play. Too much attention cannot be bestowed, on the part of the commanding officer, in seeing that his subordinates are thoroughly conversant with the character of the defences, and of all the resources that can be drawn from their position; and that this knowledge be imparted by them to the non-commissioned officers, and even to the most intelligent among the privates. The fate of a work may depend upon the good or bad conduct of one individual. The reserve is posted in the most convenient position to afford prompt assistance to any point in danger of being forced. The troops drawn up on the banquette should be carefully instructed in their duties; and they should be taught not to look for aid, or relief, from the reserve, until they have repulsed the enemy.

If the enemy opens his attack by a warm cannonade, the troops should not be exposed to it, if they can be sheltered near the posts they are to occupy when his columns of attack approach, at which time his cannonade must cease, in order not to injure his own troops. The men should be instructed to reserve their fire until the enemy has arrived at certain points marked out in front of the works, which should not be farther than two hundred yards from the parapet for smooth bores.

142. Sorties. These, if well timed, will generally decide the fate of the affair. They should be made when the assaulting column is thrown into confusion, or shows any signs of irresolution in its movements; or when its flank, or rear, is carelessly exposed. They are sometimes made to alarm the enemy for his own safety; or to make a diversion in favor of expected succors in blockaded posts.

Cavalry is the best arm for a sortie, on account of the rapidity of its movements, and the violence of its shock. When infantry is employed for this purpose, it should use the bayonet alone.

Should the enemy succeed in forcing his way into the work, the reserve should attack with the bayonet, before he has time to form; but it must be confessed that success oftener crowns an offensive movement, on the part of the assailed, in endeavoring to regain possession of their works, than any effort to drive back the enemy at the moment, when flushed with success, he has the hope of a certain victory. The only well-grounded prospect that the assailed have of repelling the assault, when the enemy has gained the top of the scarp, is to meet him in an offensive attitude at the point of the bayonet on top of the parapet.

The particular arrangements of the defence consist in defending all obstacles, such as abattis, palisadings, etc., by a warm well-aimed fire; as the particular object of these obstacles is to keep the enemy exposed for a longer time to the fire.

Large stones, heavy round logs, and loaded hollow projectiles, should be in readiness to be rolled over on the enemy whilst he is in the ditch endeavoring to mount the scarp. Large branches of trees prepared as for an abattis, with chevaux-de-frise, and other obstacles, should be at hand to obstruct the breach.

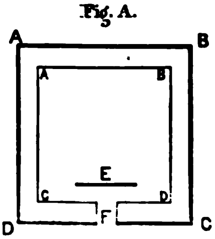
Finally, in an isolated post, if the enemy, after having been repulsed, makes a show of blockading it, or of renewing his attack, and there is no prospect of succor arriving, the garrison should attempt an escape by night.

NOTE A. (ART. 81.)

Manner of determining the relations between the terre-plein of a Square Redoubt, the development of its interior crest, and the size of its garrison.

Let A B C D (Fig. A) be the line of the interior crest; a b c d

Fig. A.



that of the foot of the banquette slope; F the outlet through the parapet; and E the interior traverse.

Representing by x, the number of yards in the side A B, the side a b will be equal to x diminished by twice the distance between A B and a b, which distance may be taken on an average at nine yards; the area of the square b c, or of the terre-plein, will then be represented by $(x-9)^2$.

Let the following notation be adopted:—

y, the number of the garrison.

r, the reserve taken from the garrison.

n, the number of ranks on the banquette for the defence.

s, the area of the terre-plein occupied by a barbette in the salient.

s', the area occupied on the terre-plein by the powder-magazine.

s'', the area occupied by the traverse, and the passage in its rear.

l, the number of yards on the interior crest for a barbette in the salient.

l', the width of the outlet F in yards.

Now, as the area allowed for each man is one and a half square yards, we shall obtain the following equation, to represent the relation between the terre-plein, the garrison, etc.

$$(x-9)^2 = 1{,}50\, y + s + s' + s'' \; ; \quad . \; . \; . \; (1)$$

this is termed *the equation of the interior space.*

As each man occupies one lineal yard along the interior crest, we obtain also,

$$4x = \frac{y - r}{n} + l + l' ; \ldots\ldots\ldots \quad (2)$$

which is termed *the equation of defence*, as it expresses the relation between the development of the interior crest, the remainder of the garrison after taking out the reserve, the number of ranks for the defence, and the length of the interior crest required for the cannon in barbette, and for the outlet.

To show the application of the equations (1) and (2), let it be required to find the side of a redoubt, and the number of its garrison, which shall be defended by two ranks on the banquette, after taking out a reserve of one-third of the whole number, and have a barbette in each salient.

By a calculation, easily made, it can be shown, that each barbette will occupy about seventy-five square yards of the terre-plein; a powder magazine for four guns, twenty square yards; a traverse of earth, with the passage between it and the foot of the banquette, about 180 yards; or, if of timber, about fifty square yards; the portion of the interior crest for each barbette will be nearly eighteen lineal yards; and that for the passage about four lineal yards.

Taking Eq. (2), and making the substitutions required by the conditions of the Prob. we obtain,

$$4x = \frac{y - \frac{1}{3}y}{2} + 4 + 72 .$$

and from it,

$$y = 12x - 228.$$

Substituting this value of y in Eq. (1), and placing for s, s', s'', their values, we have

$$(x - 9)^2 = 18x - 342 + 300 + 20 + 180 ;$$

or,

$$(x - 9)^2 = 18x + 158 ;$$

from which, by solving the equation,

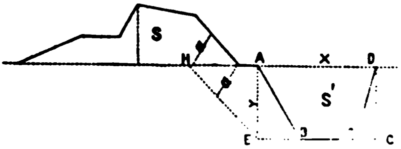
$$x = 38 \text{ yards} ;$$

consequently $y = 228$ men;
and $r = 76$ men.

NOTE B. (ART. 53.)

The Profile of the parapet, the dimensions of which are uniform at all points of the work, being given, to find the corresponding Profile of a ditch which shall furnish the embankment.

Fig. B.



Let the following notation be adopted, Fig. B.

V, Volume of the embankment.

S, Surface of its profile.

l, Line described by the centre of gravity of S in generating the embankment.

V', S', and l', corresponding values of the ditch.

Now, from the centro-baryc principle, we have

$$V = S\,l; \;.\;.\; (1), \text{ and } V' = S'\,l'; \;.\;.\; (2).$$

But, as earth, when freshly thrown up, but not rammed, occupies a greater volume than in its natural state, if this increase be represented by the fraction $\frac{1}{m}$, we shall have to represent this condition

$$V = V' + \frac{1}{m}V'; \;.\;.\;.\;.\; (3)$$

and eliminating V and V', by means of these three equations, there results

$$S' = S\,\frac{l}{l'}\left(\frac{m}{m+1}\right); \;.\;.\;.\; (4)$$

or the value of the surface of the profile of the ditch in known quantities.

Representing now by

x, the width of the ditch — A D;

y, its depth — A E;

a, the angle of the natural slope of the earth with the ground — A H E;

We obtain

$$A\,H = y \text{ Cot. } a;$$

and for the bases of the slopes of the scarp and counterscarp,

$$E\,B = \tfrac{2}{3}\,A\,H = \tfrac{2}{3}\,y \text{ Cot. } a; \text{ and } C\,G = \tfrac{1}{2}\,A\,H = \tfrac{1}{2}\,y \text{ Cot. } a.$$

we then obtain for the area of the trapezoid A B C D, which is S′, by subtracting the surfaces of the triangles A E B, and C G D, from the rectangle A G.

$$S' = x\,y - (\tfrac{1}{3}\,y^2\ Cot.\ a + \tfrac{1}{4}\,y^2\ Cot.\ a);$$

or,

$$S' = x\,y - \tfrac{7}{12}\,y^2\ Cot.\ a\ ; \ldots\ldots\ldots\ldots \quad (5)$$

an equation from which either x or y may be obtained, by assuming either the width or the depth. But as x has certain limits, from the nature of the Prob., we will solve Eq. (5) with respect to y, and will obtain.

$$y = \tfrac{6}{7}\ Tan.\ a\ (x - \sqrt{x^2 - \tfrac{7}{3}\,s'\ Cot.\ a},) \ldots\ldots \quad (6)$$

We observe here, in the first place, that the radical expression admits only the minus sign before it, because x and y are decreasing functions of each other: that x^2 cannot be less than $\tfrac{7}{3}$ S′ *Cot.* a, otherwise the expression will become imaginary; and when it is equal to it, the profile of the ditch becomes a triangle, so that the minima limits of x will be,

$$x = \sqrt{\tfrac{7}{3}\,S'\ Cot.\ a}\ ; \text{ and } x = 12 \text{ feet; (Art. 39.)}$$

and the maximum value will be found by multiplying the height of the interior crest by the denominator of the fraction which represents the superior slope, and subtracting from this result the horizontal distance between the interior crest and the crest of the scarp. (Art. 34.)

Any quantity, therefore, which is greater than the minima limits, and less than the maximum, will satisfy the conditions of the Prob., if it gives for a result y between six and twelve feet. (Art. 39.)

But should the value of y not fall between these limits, then we shall be obliged to change the form of S; and consequently find a new value of S′; making it greater or smaller, as the case may require.

To show the manner of applying this formula to practice, let it be required to find the dimensions of the ditch of a square redoubt from the following data; the command of the interior crest is eight feet; the thickness of the parapet nine feet; the superior slope one-sixth; the angle of the natural slope 45°; and the tread of the banquette four feet.

Taking, in the first place, Eq. (4),

$$S' = S\,\frac{l}{l'}\left(\frac{m}{m+1}\right)$$

a very simple calculation will show that $\frac{l}{l'}$ will be very nearly represented by the fraction $\frac{3}{4}$, for redoubts between twenty and forty yards of a side, measured along the interior crest, l′ being the middle line of the top of a ditch, which is a mean between the least and greatest limits. The value of $\frac{1}{m}$ is, in ordinary earth, about $\frac{1}{8}$, and varies generally between $\frac{1}{4}$ and $\frac{1}{12}$, so that, by substituting these values in the Eq., we have

$$S' = \tfrac{3}{4}\left(\frac{8}{8+1}\right) S = \tfrac{2}{3}\, S;$$

and the value of S, calculated from the data, being 122 square feet, we have

$$S' = 81, \text{ square feet nearly};$$

substituting this value of S′ in Eq. (6), we obtain

$$y = \tfrac{6}{7}\,(x - \sqrt{x^2 - 189});$$

from which we see that $x^2 = 189$, gives $x = 13$ feet, therefore the quantity assumed for x must be greater than this; if, then, we assume $x = 15$ feet, and substitute it in this formula, we obtain

$$y = \tfrac{6}{7}\,(15 - \sqrt{225 - 189});$$

or

$$y = \tfrac{6}{7}\,(15 - 6 = 7.7 \text{ feet};$$

which satisfies the required conditions.

It may be added, that with this width of ditch, the line of fire passes 2.6 feet above the counterscarp crest.

In the foregoing calculations, no allowance has been made for the volumes of the barbettes; and the traverse when of earth. To make this allowance, Eqs. (3) and (4) will have to undergo a suitable modification, as follows:

The cubic contents of each barbette, in a salient, is nearly 140 yards; and that of the traverse about .70 yards. If, then, the total cubic contents of all the barbettes, and the traverse, be represented by V″, a given quantity, Eq. (3) will become

$$V + V'' = V' + \tfrac{1}{m}V' \quad \ldots \text{(X)};$$

and

$$S\,l + V'' = S'\,l' + \tfrac{1}{m}S'\,l', \quad \ldots \text{(Y)}$$

Now, as V″ is a given quantity, it can be represented by S″ l, in which S″ is found by dividing V″ by l; making this substitution in Eq. (Y), we obtain

$$S' = (S + S'')\frac{l}{\;}\left(\frac{m}{m+1}\right) \quad \ldots\ldots \text{(Z)}$$

for the modified value of S′ Eq. (4), to suit this case. The operations for finding x and y, Eq. (6) are the same as already shown.

The calculations here given suppose the plane of site sensibly horizontal, and the interior crest parallel to it; when this is not so, as, for example, in a defiladed work, the volumes of the parapet and ditch will have to be calculated for each face separately.

The method of doing this, where the site is very irregular, consists in making an unequal number of parallel profiles, on each face, at equal distances from each other, and finding the area of each profile, and then using the following notation and formula,

let $s', s'', s''', s^{iv}, \dots\dots s^{n+1}$, represent the areas of the successive profiles, their entire number being $n+1$;

l, the distance between the profiles;

v, the volume between the extreme profiles; then

$$V = \frac{l}{3}(s' + 4s'' + 2s''' + 4s^{iv} + 2s^{v} \dots 4s^{n} + s^{n+1}).$$

In other cases, where the site is not very irregular, a mean profile may be found, and the Eq. (Z) be used.

It is usually best, since the dimensions of the ditch cannot be uniform throughout, to adopt a uniform depth, and to vary the width as circumstances may require.

MILITARY MINES.

CHAPTER I.

NOMENCLATURE, EXPERIMENTS, AND THEORY OF THE EXPLOSION OF MINES.

Military Mining consists in the underground operations by which both the assailed and the assailant, in a protracted defence of a work, gain positions where, by exploding large charges of powder, they are enabled to destroy each other's works, and thus retard or advance their respective objects. This method of reciprocal attack and defence is equally applicable to both temporary and permanent fortifications: the means employed in the former being of a perishable and temporary character, and resorted to only when a favorable occasion arises; whilst in the latter permanent dispositions, for the most part, are made long before they may be wanted, and materials are employed of great durability.

1. **Mine.** The term *mine* is applied both to the underground excavations charged with powder for the purpose of producing an external explosion, and to the communications which lead to these excavations.

The excavation in which the charge of powder is lodged is termed the *chamber.* The pit formed by the explosion is termed the *crater.*

2. **Crater.** The form of the crater in ordinary soils has not been accurately ascertained. The only use of the exact determination of this form would be to calculate precisely the quantity of earth thrown from the crater, and by that means to proportion the charge to the effect to be produced. Different figures have been assigned by engineers to the solids constituting the crater; some assuming it to be a cone, the centre of the powder

being taken as the vertex; others, a paraboloid, the centre of the powder being the focus, etc. To afford a uniform and simple rule for calculating the volume of the crater, the solid (Fig. 1)

Fig. 1.

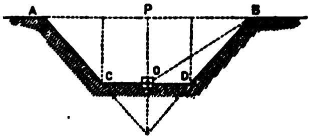


Fig. 1. Section of Crater.

will be assumed as a truncated cone, the radius O D, of the lower circle, being also assumed at one-half the radius P B, of the upper circle. The radius P B, of the upper circle, is termed the *crater radius.* The line O P, drawn from the centre of the powder perpendicular to the surface where the explosion takes place, the *line of least resistance.* The line O B, drawn from the same centre to any point in the circumference of the upper circle, *the radius of explosion.*

3. Common Mines, etc. The term *common mine* is applied to a crater when its radius is equal to the line of least resistance. When the crater radius is greater than the line of least resistance, the terms *overcharged mine,* and *globe of compression* are used. When the crater radius is less than the line of least resistance, the mine is termed *undercharged.* A small mine with a line of least resistance not greater than 9 feet, formed by sinking a shaft from the surface of the ground, and placing the charge at the bottom of it, is termed a *fougasse.* The term *camouflet* is applied to small mines used to suffocate the enemy's miners without producing an external explosion.

4. Galleries. The underground communications required for the service of mines are termed *galleries.* The galleries are either arched communications of masonry for permanent fortifications, or else a frame-work and sheeting of timber. A gallery immediately behind the counterscarp wall, is termed a *counterscarp* or *magistral gallery.* An *enveloping gallery* is one parallel to the counterscarp gallery, and at some 30 or 40 yards in advance of it. The galleries leading outwards from the counterscarp gallery are termed *listening galleries.* The galleries which connect several listening galleries are termed *transversal* or *cross* *galleries.* Galleries receive also particular names from their size, as

The great or grand galleries, which are	6 ft. high and	6 ft. wide.
Common galleries, . . .	6 "	3 "
Half galleries, ...	4½ "	3 "
Branches, ...	3½ "	2½ "
Small branches, ...	2½ "	2 "

5. **Experiments.** But little advance by experiment has been made in the subject of mines, owing to the time, labor, and expense which a prosecution of the subject demands; and the practice has therefore undergone but slight changes since the earliest introduction of this means of attack and defence. The following facts, drawn from observation, comprise almost all that is at present known on the subject.

1. In solid rock, an explosion causes the rock to split in various directions, and if the charge is heavy will break it into small fragments, which are frequently thrown to a great distance.

2. In sand, the gases seem to penetrate between the grains, producing a crater of a regular form, the radius of the upper circle of which is generally small in comparison with the depth.

3. In ordinary tenacious soils, the first effect of the explosion is to produce a rumbling noise and a sensible trembling of the earth around the mine to a considerable distance; the ground directly over the mine is next observed to rise in the form of a spherical segment, which increases perceptibly until the smoke commences to issue forth around its base; the explosion outwards follows immediately on this last phase, the earth mingled with smoke and flame being thrown upwards and outwards, so as to assume a form something like a water-spout; part of the earth falling back into the crater and a part without, forming a ridge around its mouth.

The two most remarkable features of the explosion are its internal and external effects; the first producing the crater, the second so disturbing the earth for a considerable distance around the crater as to fill up cavities, destroy empty galleries, etc., within the sphere of its action; these effects extending farther in a lateral than in a downward direction.

The charges and their effects do not follow a direct ratio, the last increasing less rapidly than the first. Experiment has shown that the charges may even be increased one or two pounds per 4 cubic yards without increasing the crater radius; the only effect of this increase of charge being to throw more of the earth clear of the crater.

From experiments made on common mines with a line of least resistance not exceeding 15 feet, it has been ascertained that the tenacity of the earth is completely destroyed around the crater, to a distance equal to the line of least resistance, and that empty galleries are broken in at a distance of one and a half the same line.

In homogeneous soils the resistance due to the tenacity of the soil is nearly proportional to the mass.

It was for a long time supposed by miners that a crater could not be formed with a radius greater than twice the line of least resistance with any charge; but the experiments of Belidor have shown that, by successive augmentations of the charge, the crater radius may be increased to six times this line, but not much beyond; that within this limit the ratio of the diameters of the craters is nearly that of the square root of the charges; and that galleries can be destroyed by such mines at distances of four times their line of least resistance.

6. **Theory.** The physico-mathematical theory of mines is still very imperfect, owing to the impracticability of ascertaining the exact effects of the explosion of powder in a medium which is seldom homogeneous, and the resistance of which, arising from its tenacity, compressibility, etc., to the expansion of the gases, can only be arrived at by a wide range of experiments made with minute care.

From the want of these elementary data, the formulæ at present in use, to determine the charges for different media, are necessarily empirical, and their results are to be relied on only within the limits in which they coincide with experiments. For most cases in practice, these approximations are near enough, and valuable as the only guides that the miner has to refer to.

The resistances which the gases overcome are the weight of the volume of earth thrown from the crater, the tenacity of the medium, and the atmospheric pressure on the upper circle of the crater. The two first are proportional to the mass of earth thrown out, and the last to the upper surface of the crater. To express the ratio of these resistances to the charges, represent in any two mines by,

c, c' the charges,

r, r' the radii of the craters,

l, l' the lines of least resistance,

d, d' the weight of the unit of volume of the two soils,

n, n' the constants, which multiplied into the weights will express the resistance due to the tenacities.

h, h' the heights of the atmospheric columns reduced to the densities as the soils.

Then whatever may be the form of the crater, its volume can be expressed in terms of the surface of the upper circle and some fractional part of the line of least resistance; so that if this fractional part of the line of least resistance, in the two cases, be represented by $\frac{1}{m}$ l and $\frac{1}{m'}$ l' the contents of the two volumes will be expressed respectively by

$$\pi r^2 \times \frac{l}{m}, \text{ and } \pi r'^2 \times \frac{l'}{m'};$$

their respective weights,

$$\pi \frac{r^2 l}{m} \times d, \text{ and } \pi \frac{r'^2 l'}{m'} \times d';$$

the resistances due to the tenacities by,

$$\pi \frac{r^2 l d}{m} \times n, \text{ and } \pi \frac{r'^2 l' d'}{m'} \times n';$$

and the weights corresponding to the atmospheric pressures, by,

$$\pi r^2 h d, \text{ and } \pi r'^2 h' d'.$$

From these expressions, as the charges are supposed to be proportional to the resistances, there obtains,

$$c : c' :: \frac{r^2 d}{m}[(n+1)l+mh] : \frac{r'^2 d'}{m'}[(n'+1)l'+m'h'].$$

But for the same soil, as m=m', n=n', d=d', and h=h', this proportion becomes

$$c : c' :: r^2 (l + \frac{m}{n+1} h) : r'^2 (l' + \frac{m}{n+1} h') \;.\;.\;.\; (A)$$

The relation between any two charges of mines in the same soil, expressed by this proportion, gives the means of obtaining the charge for any crater when, by experiment, the crater formed by any known charge has been found, provided the quantities n and h are also known. Of the first nothing definite is known but that it varies with the kind of soil. The second has been assumed equal to 11 feet. This want of definiteness in the value of these quantities has led to omitting them in the proportion, when used for practical purposes; in which case it takes the following form:

$$c : c' :: lr^2 : l'r'^2 \ . \ . \ . \ (B).$$

This is termed the *Miner's Rule*, as it is used for calculating tables of charges for different soils; and its results do not differ materially from those of experiments.

Making $l=l'$ the proportion becomes

$$c : c' :: r^2 : r'^2, \ . \ . \ . \ (C)$$

a proportion also differing but little from the results obtained within the ordinary limits of practice, when the lines of least resistance are the same for different charges.

Assuming, as is the case in common mines, that the craters are similar solids, then $l : l' :: r : r'$; hence,

$$c : c' :: l^3 : l'^3, \ . \ . \ . \ (D)$$

another form of the Miner's Rule; and the one used in calculating the tables of charges for similar mines.

The manner in which this rule is applied to calculate charges of common mines is as follows: the quantity of powder q, in pounds, required to throw up one cubic yard of any species of soil, is found by experiment. As the solid contents of a truncated cone, like Fig. 1, is equal to $\frac{11}{6}l^3$, l being the line of least resistance, the volume of the crater, whose line of least resistance is one yard, will be represented by $\frac{11}{6} \times (1^3)$ or $\frac{11}{6}$; this volume multiplied by q will give the charge in pounds for this crater; but from the proportion $c : c' :: l^3 : l'^3$ there obtains,

$$c : \tfrac{11}{6}q :: l^3 : 1^3, \text{ or } c = \tfrac{11}{6}ql^3, \ . \ . \ . \ . \ (E)$$

for the charge for a crater whose line of least resistance is l. *To find the charge, therefore, for a given line of least resistance, cube this line, expressed in yards; take* $\frac{11}{6}$ *of the result and multiply it by the number of pounds required to throw out a cubic yard of the soil in question.*

The following table gives the values of q:

Light sandy earth	1 lb.	13 oz.
Hard sand	2 "	00 "
Common earth.	1 "	10 "
Wet sand	2 "	2 "
Earth mixed with pebbles . .	2 "	8 "
Clay mixed with loam . . .	2 "	8 "
Rock	3 "	10 "

As the Miner's Rule is applicable only to common mines, resort must be had to some other to find the charges for overcharged and undercharged mines. The formulæ in most general use for these cases are those of Lebrun, a French engineer, which, although not based on any satisfactory hypothesis, nevertheless coincide nearly in their results with those obtained by experiments made within ordinary limits. The hypothesis assumed to obtain these formulæ is as follows: Suppose two craters, formed by two different charges c and c′, with the same line of least resistance; one giving a crater radius r, obtained from calculation, equal to the line of least resistance, the other a crater radius R, greater than it, the difference of the two radii being R—r; next suppose the charge c′ to belong to a common mine of which the crater radius, also obtained from calculation, is r′; r′—r, being the difference of the radii of two craters of the common mines of which the charges are c and c′; then it is assumed that the ratio of the two differences here expressed, arising from the same increase, c′, of the charge c, will be constant under all circumstances of variation of soil, and of the lines of least resistance. Calling K this constant ratio, there obtains from the hypothesis,

$$\frac{R-r}{r'-r} = K;$$

now assuming R=nr, n being greater than unity, this formula becomes

$$\frac{r(n-1)}{r'-r} = K,$$

or,

$$\frac{r'}{r} = \frac{1}{K}(n-1)+1;$$

but as r′ and r belong to similar craters, the Miner's Rule gives $\frac{c}{c'} = \frac{r^3}{r'^3}$; from this there obtains,

$$c' = c\left[\frac{1}{K}(n-1)+1\right]^3. \ . \ . \ . \ (G)$$

The quantity K which enters into this expression is ascertained by experiment, as indicated by the process followed in obtaining the formula. From a comparison of a number of experiments the value of K gives

$$c' = c\,(0.91\,n + 0.09)^3. \ . \ . \ . \ (H)$$

The preceding method is also applied to find a formula for the charges of undercharged mines. In this case, R and r′ being supposed less than r, and n, therefore, less than unity, then $\frac{r-R}{r-r'} = K$, and hence formula (G) becomes, $c' = c\left[-1\frac{1}{K}(1-n)\right]^3$. The constant K in this case, is determined from a deduction made from a result of experiment; which is, that if a certain charge of powder forms a common crater with a line of least resistance, l, then the same charge will not produce any external effect when the line of least resistance is increased to 1¾ l, or $\frac{7}{4}$ l; and, conversely, if a charge produces no external effect with a line of least resistance, l, the same charge will form the crater of a common mine under a line of least resistance $\frac{4}{7}$ l. If, then, the charge c′, by supposition, does not produce any external effect under the line of least resistance, l, it will produce a common mine under a line of least resistance $\frac{4}{7}$ l; from this, by the Miner's Rule, there obtains

$$c' : c :: (\tfrac{4}{7}l)^3 : l^3,$$

or,

$$c' = c\,(\tfrac{4}{7})^3.$$

Now substituting this value of c′ in Eq. (G), n corresponding to this value of c′ becoming zero, there obtains $\frac{1}{K} = \frac{3}{7}$, which result substituted in the same Eq. (G) it then becomes

$$c' = c\left[1-\tfrac{3}{7}(1-n)\right]^3; \text{ hence } c' = c\left(\frac{3n+4}{7}\right)^3, \ . \ . \ . \ (I)$$

which is the formula for undercharged mines.

CHAPTER II.

PRACTICAL DETAILS AND OPERATIONS.

7. Wooden Galleries. Temporary galleries are made of frame-work covered in by plank, and are prepared but a short period before they are required for use.

The frames of temporary galleries consist of four pieces: two uprights termed *stanchions*, and two horizontal pieces; the one at top termed a *cap sill*, and the bottom piece a *ground sill*. The parts of the frame are connected as shown on (Fig. 2).

Fig. 2.

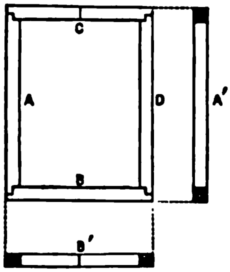


Fig. 2. Gallery Frame. A, A' Stanchions, C Cap, B, B' Ground Sill.

The plank or boards which cover in the frames are termed *sheeting*. The top sheeting of the frames usually consists of boards from 3 ft. 6 in. to 4 ft. in length, from 7 to 12 in. in width, and from 1 to 1½ in. thick. The side sheeting may have the same length and breadth, but need not be thicker than from ¾ to 1 inch. To set the frames up and retain them in their places, slips of plank termed *battens* are used, which are about 2½ in. wide and 1 in. thick.

The frames may be either of well seasoned oak or pine; the latter is preferable, as lightest. The parts of each frame receive the dimensions in the annexed table.

GALLERIES.	GROUND SILLS.	STANCHIONS.	CAP SILLS.
Great gallery	6 × 4½	6 × 6	7 × 6
Common gallery	5 × 4	5 × 5	6 × 5
Half gallery	4½ × 3½	4½ × 4½	5 × 4½
Branches	3½ × 3	3½ × 3½	4½ × 3½
Small branches	3 × 3	3 × 3	4 × 3

3. Wooden Shafts. A shaft is a vertical pit made in the earth and lined with sheeting to keep the soil from caving in, frames being placed horizontally and at suitable intervals apart to sustain the pressure on the sheeting.

The cross sections of shafts are either square or rectangular; the dimensions of the sides of the section depending on the object of the shaft. When the object is to drive a gallery from the bottom of the shaft, the dimensions of the shaft frames, in the clear, must be at least equal to that of the gallery, measured from out to out of its sheeting. A shaft sunk for establishing a mine-chamber simply, should usually be of the least dimensions; which, to allow the miner to work with facility, are at least 3 ft. by 2 ft. in the clear.

Two kinds of frames are usually requisite in sinking shafts, a *Top Frame* (Fig. 3), formed of four pieces, halved to fit each

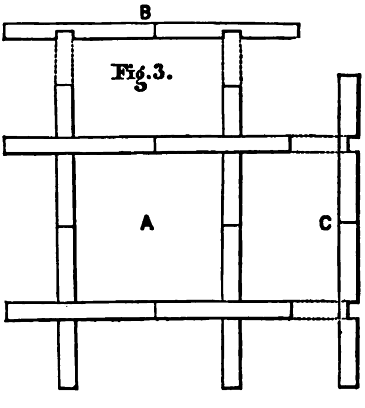


Fig. 3. Top Shaft Frame. A, Plan; B Upper, C Under Piece.

other, which, when put together, have the same dimensions in the clear as the shaft; each piece projecting beyond the sides, or having an *over length* of 1½ to 2 ft., and a *Side Frame* (Fig. 4), which also consists of four pieces of smaller scantling than the top frame, halved at the ends to fit; its dimensions from out to out being the same as of the top frame in the clear.

Fig. 4.

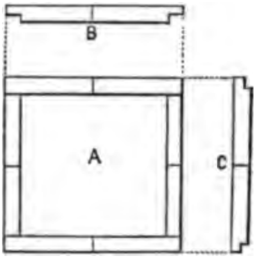


Fig. 4. Common Shaft Frame. A, Plan; B, Upper, C, Under Piece.

In very loose soil it may be necessary to use a temporary frame (Fig. 5), termed an *Auxiliary Frame.* This is somewhat larger in the clear than the ordinary shaft frame, and is used only for a temporary purpose in setting the ordinary frame.

Fig. 5.

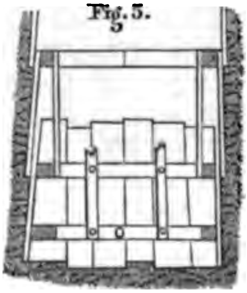


Fig. 5. Vertical Section of Shaft, showing Auxiliary Frame at O.

The opposite pieces of each frame are marked with a saw-cut, termed a *score*, at their middle, on the upper side. The scores serve to fix the position which the frame should occupy when laid.

The scantling for top frames is usually 6 in. square; that of side and auxiliary frames 4½ in. for a shaft over 4½ ft. in the clear. For smaller shafts the scantling may be of smaller dimensions.

9. Shaft Intervals. The term *Interval*, both in shafts and galleries, expresses the distance between two adjacent frames added to the thickness of the scantling of one frame, and measured in the direction of the axis of the shaft, etc. With scantling and sheeting of the usual dimensions, the interval should not be greater than 3½ ft.

Prob. Fig. 6. *The depth of a shaft, and the height of a gallery to lead from the bottom of the shaft, being given, to estimate the shaft interval.*

Fig. 6.

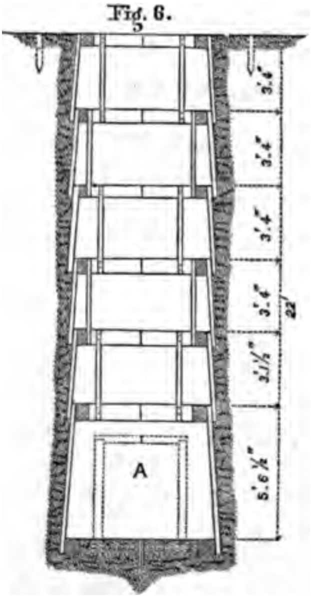


Fig. 6. Vertical Section of Shaft showing the Frames and Gallery A at bottom of Shaft.

To do this, take the height of the gallery frame, estimating from the top of its ground sill to the top of the cap sill; the thickness of the top sheeting; and the thickness of the shaft frame; two inches for free space between the gallery frame and the shaft frame next above it, to introduce the top sheeting, and add them into one sum; subtract this sum from the total depth of the shaft, and divide the remainder into any convenient number of equal or unequal intervals, each not greater than 3½ feet, for the shaft interval required.

Example. Let the depth of the shaft, for example, be 22 ft., and the height of the gallery 4 ft. 6 in. Then:

From ground sill to exterior of top sill	4 ft.	11 in.
Top sheeting	0 "	1 "
Shaft frame	0 "	4½ "
Free space	0 "	2 "
Total	5 "	6½ "

This taken from 22 ft. leaves 16 ft. 5½ in., which can be divided into four intervals of 3 ft. 4 in. each, leaving one interval of 3 ft. 1½ in. which may be placed either at top or bottom, but better in the latter position.

10. Construction of Shafts. To construct the foregoing shaft in a loose soil, there will be required a top frame; five side frames for the intervals above estimated; two for the remaining lower portion of the shaft; one auxiliary frame; four battens for each interval, each of the length of the interval added to the thickness of the shaft frame; from twelve to twenty square pickets about 18 inches long; with the machinery and mining tools requisite for the operation.

The work is laid out by first driving a picket to mark the axis of the shaft, and two others which, with the first, should be in the vertical plane containing the axis of the gallery. A level bed is then made for the top frame; the pieces of which are accurately laid and confined by pickets, one at the end of each piece; care being taken to drive the two pickets of each piece at the same time, so that their true position may be kept. Other pickets may be driven temporarily on the outside of the frame, at the angular points. After the frame is laid, the accuracy of its position is tested by seeing whether the distances from the centre of the central picket to the interior angular points, or, in other words, the *semi-diagonals* of the figure, are equal; if they are, the position is correct.

The excavation is next commenced, and, if the crumbling of the soil does not interfere, may be carried as far as the position of the first frame below the top frame; the sheeting boards, inserted between the sides of the excavation and the exterior of the top frame, being gradually advanced with the excavation.

Having reached its place, the first side frame is hung by four battens, two being nailed to each piece of the opposite sides of the top frame, and to the two corresponding pieces of the side frame, the halvings of which are turned upwards; after these pieces are adjusted by their scores, and firmly fixed by the battens, the other pieces are laid on them, with the halvings down, and secured by nails.

This frame being fixed, the ends of the sheeting of the next interval may be inserted between it and the sheeting of the first interval, and the excavation continued. The soil now becoming troublesome by its crumbling, measures must be taken to retain it firmly until the second frame is laid. For this purpose the auxiliary frame (Fig. 5) is introduced, and hung midway in the interval, as the ordinary frames. The sheeting which, thus far, has been gradually advanced with the excavation, is also inclined outwards at bottom, to gain room for the auxiliary frame, by wedges inserted between the boards of the two intervals. After the auxiliary frame is fixed, the excavation and sheeting are carried on to the end of the interval, the next frame is hung, and the sheeting for the new interval introduced. The auxiliary frame is now removed and placed in the next position it is to occupy, when reached by the excavation. The work proceeds in this order until the shaft is completed; then a picket is driven in the bottom to make the central point.

Remark. A sketch, made to a suitable scale, should be in hand for immediate reference in conducting such works. This is more particularly necessary for gallery work, the sketches for which should be very accurately drawn, referenced, and numbered; as they serve not only for reference to guide the miner, but to determine positions and dimensions of some of the important portions.

11. Combinations of Wooden Galleries. A gallery which leads from another is termed a *Return Gallery;* and is called either an *Oblique* or *Rectangular Return*, according to whether the projections of the axes of the two galleries make a right or an acute angle with each other. The gallery from which the return is made is termed the *Gallery of Departure.* When the floor of the return rises or falls from that of the departure, the return gallery is termed *Ascending* or *Descending.*

12. Working Plans. To make a working sketch of a combination of galleries, the projections of the axes are first laid out; their points of intersection marked; and the distances and reference between all the points written. The half width of each gallery in the clear being next set off on each side of its axis, lines are drawn parallel to it, then parallel and exterior to these, at the thickness of the gallery frame from them, two others; and finally, two more to make the exterior line of the sheeting.

In Figs. 7, 8, 9, the line C D is the axis of the gallery of departure, and A B that of the return. The line A B is the interior line of the gallery frames; C D the exterior line of the same; E F that of the sheeting. The corresponding lines for the remaining half of the gallery of departure, and those of the return, will be readily recognised. The frames M and M′ bound the entrances or *Landings* to the returns.

Fig. 7 is a sketch of a working plan for a right or rectangular

Fig. 7.

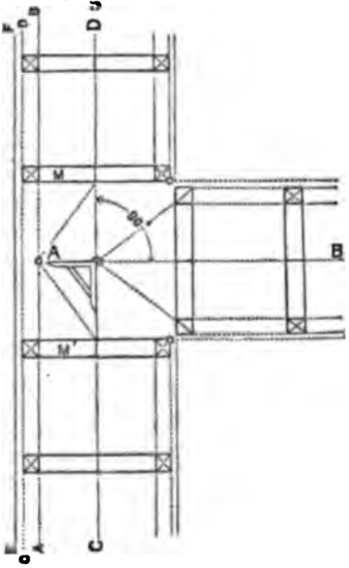


Fig. 7. Plan of Gallery and Rectangular Return.

return. The frames M, M′ of the landing, in the gallery of departure, are so far apart that, were the return gallery all of one piece, it could be shoved in or out between them. The same idea regulates the relative positions of the landing frames of the gallery of departure, and the return gallery in all other cases.

In oblique returns (Fig. 8), where the angle between the axes of the two galleries is 45° or greater, the return is run directly from the main gallery. The first frame of the return being an oblique one, having its stanchions and sills cut with a suitable obliquity, so that, when the frame is placed alongside of the main gallery, the outside of its stanchions will lie parallel to the axis of the return. The position of the landing frames M, M′ is so determined that one of the exterior lines of the sheeting of the return will intersect the exterior edge of the stanchion of M at O, and the other the interior edge of M′ at O′.

Fig. 8.

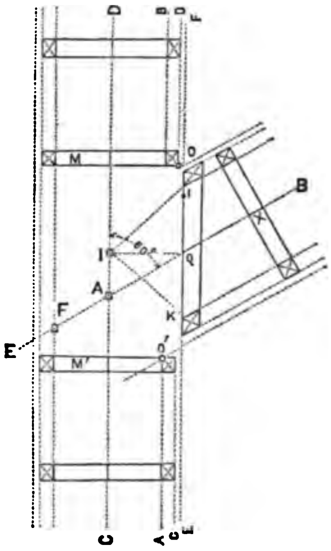


Fig. 8. Plan of Gallery and Oblique Return of 60°.

When the angle between the axes is less than 45° (Fig. 9), it would give too wide a landing in the gallery of departure to run the return directly from it. A short rectangular return must first be made to serve as a landing to the oblique return. To determine the position of the rectangular return, so that it shall be the shortest practicable, set off the lines of the gallery of departure and of the oblique return in the usual manner, draw a line R S parallel to the axis C D, and at the thickness of the gallery frame of the rectangular return from the

Fig. 9.

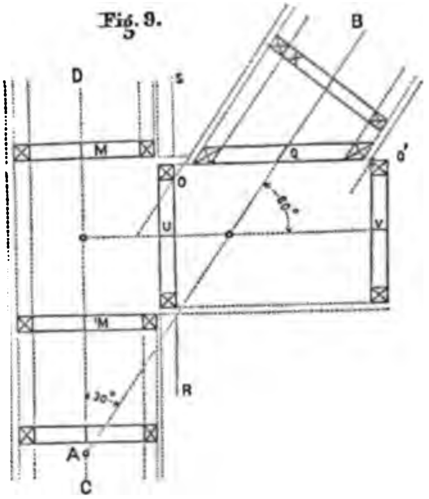


Fig. 9. Plan of Gallery, with Rectangular Return to form an Oblique Return of 30° with Main Gallery.

exterior line of the sheeting; the point O, where this line cuts the exterior line of the sheeting of the oblique return, will be the position of the interior edge of the stanchion of the gallery frame U, of the rectangular return; having next drawn the lines of this return, the position of the other frame, V, will be at the point O', where the outside line of the stanchions of the rectangular cuts the outside line of the sheeting of the oblique return. The landing frames, M and M', of the gallery of departure are placed just far enough apart to leave room for the insertion of the sheeting of the rectangular return.

When a slight change of direction is to be made in the gallery of departure (Fig. 10), the angle C A B of the change of direction is bisected by the line A E, which is taken as the axis of a short return just large enough for the miners to work in to carry forward the new direction. The figure explains itself.

Remarks.—From an examination of the above cases, it will be seen that the object to be accomplished is so to place the two frames of the gallery of departure, which bound the entrance to the return, that the stanchions of these frames shall not be in the way of the miner, when pushing forward the side sheeting; or,

Fig. 10.

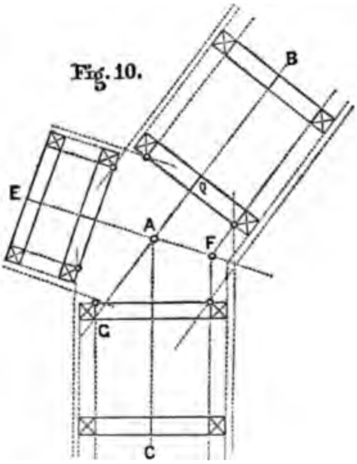


Fig. 10. Plan of Recess, E, for effecting a slight change of direction in a Gallery.

in other words, if the return were a box that could be pushed forward, like a drawer, in the direction of its axis, the stanchions in question should not hinder this movement.

Several other problems of a like character may present themselves in returns, and in changes of direction in galleries, which it will be unnecessary to treat here, as the illustrations above given will readily suggest the methods to be adopted for their solution.

Having set off all the lines on the working sketch, and marked the positions of the different frames, etc., at the junctions of the galleries, their forms, dimensions, and also their exact positions with respect to any fixed point can be accurately determined from the scale of the sketch, and be written upon it for reference in conducting the work. For example, in Fig. 8, the determination of the points O and O′, fixes the positions of the gallery frames M and M′; and the form, position, and dimensions of the oblique frame Q of the return where the galleries join. Having set off these parts, the point I—on the axis of the gallery of departure, equidistant from the points K and I of the frame Q—can be determined. This point I, with the point F, where the axis A B cuts the interior line of the stanchions, will give on the ground the direction of A B.

13. Landings. The portion of the floor of the gallery, between the frames that bound the entrance to a return, is termed a *Landing;* as, for example, the spaces between the frames M, M′, and U, V. The landing is in all cases horizontal, as well as that portion of an oblique return between the oblique frame Q, and the one, X, next succeeding, which last should not be placed further than an ordinary interval from the furthest point of Q.

14. Gallery Intervals. Having determined, by means of the working sketch, the landings and their frames, with respect to the points of intersection of the axis of the gallery of departure with those of the returns, the intervals of this gallery can be calculated, and their positions marked out on the sketch. The manner of making this estimate will be best illustrated by the following example:

Let A B = 118 ft. (Fig. 11) be the total length of a gallery of departure, estimated horizontally along its axis, from the central picket of the shaft from which the gallery starts. At the point C, 44 ft. from A, the axis of a rectangular return commences; and at D, 44 ft. farther, that of an oblique one. The part A C of the gallery (Fig. 12) is to be a common great gallery; the part C D a common gallery; and the part D B a great branch. With these data, it is required to determine the intervals for the different portions of the gallery.

Fig. 11.

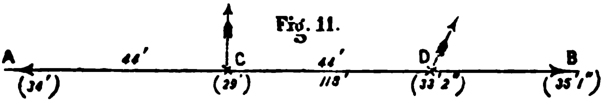
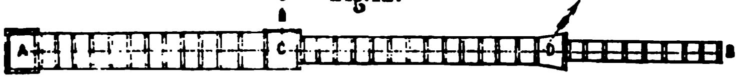


Fig. 12.



To find the interval for the first portion, A C, subtract from the total distance, 44 ft., the following aggregate:

Half the width of the shaft in the clear .	2 ft. 2 in.
The thickness of the lowest shaft frame .	0 " 4½ "
Half the width of the landing at C . .	2 " 0½ "
The thickness of a gallery frame at the landing	0 " 5 "
	5 " 0 "

which leaves 39 ft. to be divided into suitable intervals; which may be done by making twelve of them, each 3 ft. 3 in.

The intervals of the portion, C D, will be found as follows. From 44 ft. take the following sum:

Half the width of the landing at C . .	2 ft. 0½ in.
Thickness of the landing frame . .	0 " 5 "
The distance from D (as found from sketch) to the landing frame back . . .	0 " 9 "
Thickness of gallery frame at landing D .	0 " 4½ "
	3 " 7 "

which leaves 40 ft. 5 in. This can be divided into nine intervals, each 3 ft. 1 in.; and four of 3 ft. 2 in. each.

To find the intervals for the part D B, from 30 ft. take the following aggregate:

Distance from D to frame of landing beyond it	4 ft. 5 in.
Thickness of landing frame beyond D .	0 " 3½ "
Thickness of last frame at B . . .	0 " 3½ "
	5 " 0 "

This leaves 25 ft., which can be divided into six intervals of 3 ft. 2 in. each, and two of 3 feet.

15. Slope Block. In setting the ground sills of frames in ascending or descending galleries, a small cubical block of wood, termed a *Slope-block*, is used, the height of which is equal to the difference of level between the ground sills of an interval. To determine the height for any portion of a gallery where the intervals are equal, or nearly so, the difference of level or of reference of the two extremities of this portion must be divided by the number of intervals. Thus, in the portion of the gallery from A to C, Fig. 11, there is an ascent of 5 ft. or 60 in., and twelve intervals; the edge of the slope-block will, therefore, be $\frac{60}{12} = 5$ in. In the portion from C to D, there is a fall of 4 ft. 1 in. or 49 in., and thirteen nearly equal intervals; the edge of the slope-block will, therefore, be 3 ft. 7 in. nearly.

16. Auxiliary Frame. In loose soils, besides the ordinary gallery frames, there is required, as for shafts in the same soils, an auxiliary gallery frame. This frame (Figs. 13 and 14) is somewhat wider than the ordinary gallery frame, and somewhat shorter than it. Its cap sill is rounded on top, and has two mortices on its lower side, to receive the tenons with which the two stanchions are finished. The mortices are a little longer than the tenons; the latter being confined in them by wedges when the frame is set up. To adjust the frame when set up, a pair of folding wedges is placed under each end of its ground sill. By these contrivances the frame can be readily set up or taken apart.

Fig. 13.

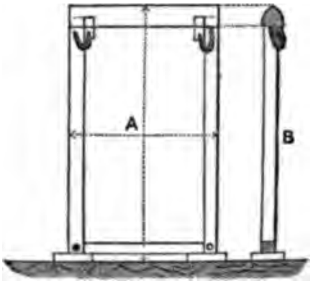


Fig. 13. Front elevation A, and Side elevation B of Auxiliary Gallery Frame.

Fig. 14.

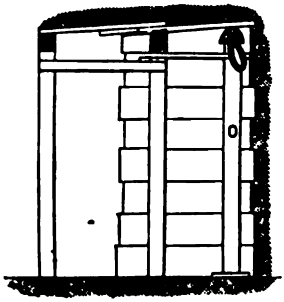


Fig. 14. Vertical Section of Gallery through the axis showing Auxiliary frame O in position.

17. Construction of Galleries. To explain the practical operations in driving a gallery, let an example be taken where the soil is loose, and the floor of the gallery rises from the point of departure. In this case the first frame of the gallery O (Fig. 15) must be set up within the shaft and against the shaft frames, on the side from which the gallery is to open. The ground sill of this frame being laid, the stanchions are secured to the intermediate shaft frames of the last interval by battens,

Fig. 15.

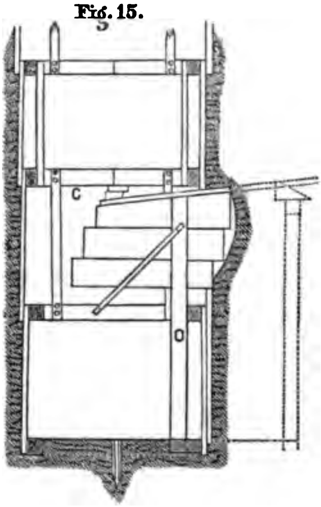


Fig. 15. Vertical Section through axis of Shaft and Gallery, showing entrance into Gallery in Loose Soil.

and the top sill fastened. A horizontal beam, C, is then secured to the under side of the top shaft frame of the same interval, to preserve the proper slope for the top sheeting when inserted; wedges being placed between this beam and the sheeting board for this purpose. A like arrangement for the side sheeting may be made if necessary. The excavation of the gallery is now commenced at top, by forcing down with a crow-bar the sheeting of the shaft, on the side of the gallery. The earth is removed gradually forwards and downwards, and the gallery sheeting advanced at the same rate. When the excavation has reached as low as the intermediate shaft frame, the piece of it that sustains the lower portion of the sheeting is removed to allow the excavation to proceed. When in this way the earth is removed as far as the middle of the first interval, the auxiliary gallery frame, Fig. 14, is set up, to support the top and side sheeting until the second gallery frame is placed. To place this last frame, the position of the ground sill is first determined, Fig. 16, by placing the slope-block, O, on the ground sill first laid, and then, by a common mason's level, A, upon the side of which the interval is marked, laid upon the slope-block, bringing the top of the ground sill on the same level as that of the slope-block. The sill being adjusted and firmly secured, the stanchions are next set up, and secured by battens to the stanchions of the first frame, and the cap-sill is secured in the last place. The adjustments of the stanchions and cap-sills are made by an ordinary plumb-line, by means of which the edges of the stanchions are placed vertically, and the scores on the cap and ground sills brought into the vertical plane of the axis of the gallery.

The battens are placed horizontally. In a level gallery they are nailed alternately at 4 and 8 in. below the cap sill. In others (Fig. 16), they are nailed 4 in. below the lower of the cap sills of the two frames which they unite; this will bring them to 4 in., added to the height of the slope-block, below the other.

Fig. 16.

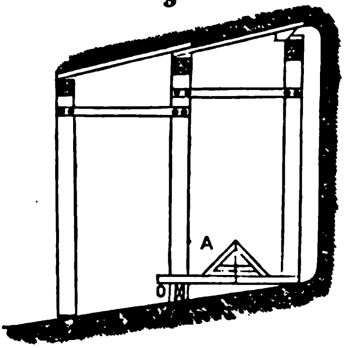


Fig. 16. Vertical Section of the Ascending Gallery through the axis, showing the Slope Block O, and Level A.

The auxiliary frame is not taken down until wedges have been placed between the sheeting and the frame last placed, in order to introduce the boards for the next interval; and these last are kept in the proper direction, as the excavation is advanced, by wedges inserted between them and the sheeting of the interval finished.

18. Branch Galleries with Dutch Cases.—These galleries are of the same dimensions as small branches. The frames are made of thick plank, and are placed in the branch galleries touching each other, serving both as frames and sheeting.

Each case consists of four pieces; the stanchions have a tenon at each end (Fig. 17), fitting into notches cut in the cap and ground sills to receive them.

Fig. 17.

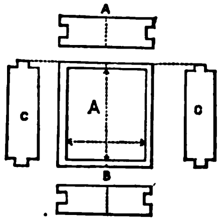


Fig. 17. Elevation A, and Side Pieces A B, C D of frame of Dutch Case.

When the gallery is an ascending or descending one, the ends of the stanchions may be cut obliquely, in order that their sides may always be vertical; or the ordinary cases may be set so as to be perpendicular to the gallery floor.

For the purpose of limiting the explosive effects of mines upon the branches leading to them, and at the same time enabling the miner, acting on the defence, to push forward and open a new branch towards the crater, a portion of a branch leading towards the mine is made of heavy frames of the foregoing construction. The timber recommended for the purpose (Fig. 18),

Fig. 18.

Plan.

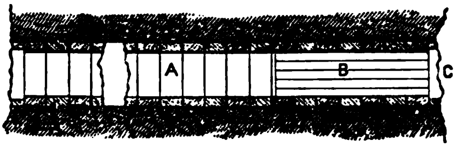


Fig. 18. Plan of Offensive Branch. A, Empty portion of the Branch; B, Portion filled with Scantling; C, Branch of common cases about 6 feet long, leading to Chamber.

is oak and the pieces of each frame are 12 in. wide and 4 in. thick. The portion of this strong frame work, at the extremity, is solidly filled in with pieces of 4 in. scantling, from 6 to 10 ft. in length. For a branch 28 in. high and 24 in. wide, seven horizontal layers will be required, each layer consisting of 6 pieces. The centre piece of each layer may have a rope handle at its end to allow of its being drawn out readily. Filled in this way and having earth well packed between the pieces, branches of this description will not be damaged by the explosion of mines of from 6 to 10 ft. line of least resistance even when the mines are within 4½ to 6 ft. of the branch. From their chief object these branches are termed by the French *rameaux de combat.*

19. Shafts à la Boule.—These shafts are lined with frames made of plank, as shown in (Fig. 19).

Fig. 19.

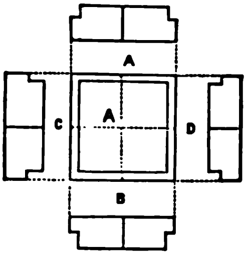


Fig. 19. Plan A, Under pieces, A B, and Top pieces, C D, of Shaft Case.

In (Fig. 20), a section of a shaft *à la Boule* is shown, which is

Fig. 20.

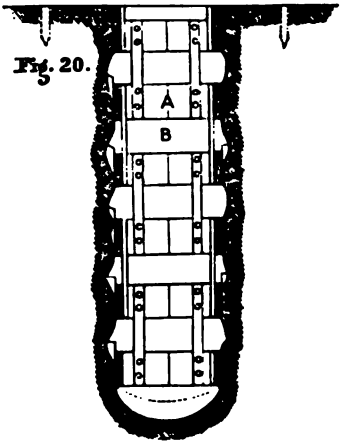


Fig. 20. Vertical Section through axis of shaft partly lined with Dutch cases. A, case; B interval.

sufficiently explanatory to render any other description unnecessary.

This kind of shaft can only be used with advantage in favorable soil, on account of the difficulty of introducing the frames sufficiently near each other: they are commonly placed one foot apart, as shown in the figure. Large gabions, 6 ft. long, and from 3 ft. 6 in. to 4 ft. in diameter, are sometimes used for lining shafts, near the surface, smaller gabions being introduced as the work is proceeded with.

For the purposes of quickly establishing small camouflets and fougasses, a boring apparatus has been resorted to, the diameter of the boring tool being 4 in. This machine is worked like ordinary tools of this kind. The chamber is charged by inserting powder in cylindrical cartridges of somewhat less diameter than the shaft, which are well pressed forward. If a large charge is requisite the end of the shaft can be enlarged by a tool with a joint, which will admit the tool to be so adjusted as gradually to increase the excavation at the end. Excavations made in this way are termed *artesian* shafts, or branches.

20. Mine Chambers.—The chamber of a mine is a cavity, formed to receive the charge of powder.

When the chamber is made at the end of a gallery, the centre of the chamber is placed on a level with the floor of the gallery. It is usually better to place the chamber at the end of a small branch return on one side. When the charge is not to be exploded immediately, or the ground is much saturated with moisture, it should be placed in a well pitched wooden case, a good cask, or in a wooden case covered with tarpaulin, or any like expedient adopted that may be at hand; the best receptacle is a water-tight tin case.

In dry ground, and when the charge is to be soon exploded, canvass bags will answer.

If the case to contain the powder is cubical and not more than 2 ft. on the edge, it may be introduced into the chamber ready made; if of greater dimensions, it must be put together in the chamber, the pieces to form the sides being arranged like the cases of branches.

An opening is made in the cover near the side about 4 in. square, for the introduction of the charge, and a similar one in the side near the centre to receive the hose through.

21. Charges.—The edge of a cubical case to contain a given charge is calculated on the supposition that 58.5626 lbs. of powder are equal in bulk to a cubic foot; and that 1000 cubic inches will therefore contain 33.89 lbs. From this, if P represents the given number of pounds of powder, and X the side of the cube sought in inches; then

$$33.89 : (10^3) :: P : X^3,$$

$$X = 3.09 \sqrt[3]{P}.$$

That is, to obtain the edge of the cubical case in inches, extract the cube root of the given number of pounds of powder, and multiply it by 3.09, or $3\frac{1}{10}$, nearly.

From the bursting of guns, where the wad has not been pressed down on the powder, it has been thought that in charging mines a like increase of effect would be produced, by leaving a certain free space around the case. Experiments on this point have not been sufficiently decisive to lead to the adoption of this in practice.

22. Hose-Troughs.—The hose-trough is a small wooden channel, in which is placed a linen bag termed the *powder-hose*, filled with powder, to fire the charge.

The bag should be of close texture and well sewed.

These troughs are made 1½ in. square in the clear. The four pieces of which they are composed, the sill, sides and top, or cover, are from ¼ to ½ in. each in thickness.

A trough should penetrate the powder case about 4 in., and should exactly fit the opening left for it.

It is fastened to the floor of the branch by nails, through the sill, which enter small pickets driven to receive them. Sometimes the sides of the trough are confined by pickets to prevent its being disturbed.

The different lengths of the trough should be cut to fit exactly. Each portion of the trough should have its cover well fitted and secured with one peg only, in order that it may readily be removed to introduce the powder-hose.

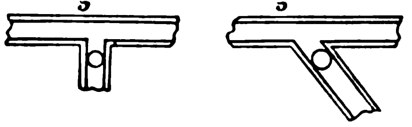


Fig. 28. Fig. 29.

Figs. 20 bis. Plan of Rectangular and Oblique Elbows of Hose-Troughs.

The trough is said to make an elbow when it changes its direction. The pieces forming an elbow (Figs. 20 bis) should be solidly yet simply connected.

23. Proportioning Trains.—When several mines are to be fired at the same moment, it is necessary so to proportion the trains to explode them, that, starting from the same point, the distances in time from that point to the charges may be all equal. The following cases show the manner of obtaining this result.

For two charges (Fig. 21), place a trough on the shortest line from the one to the other, mark the centre of it, and let the principal trough join it in that point.

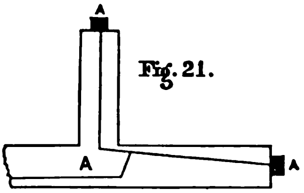


Fig. 21. Plan of Train for Firing the Two Charges, A A.

For three charges (Fig. 22), connect, as above, the two which are nearest. Let a trough lead from the middle point of this to the third charge; bisect the whole length of trough between this third charge and either of the others; then let the principal trough be joined to this last point.

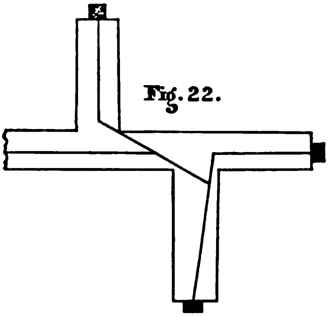


Fig. 22. Plan of Train for Firing Three Charges.

For four charges (Fig. 23), first connect them two and two, then join the central points and proceed as above.

The elbows of a trough impede the communication of the fire, for which an allowance must be made when proportioning the trains, each elbow being valued at 3 in.; thus if on one side of the point where the principal trough connects is one elbow more

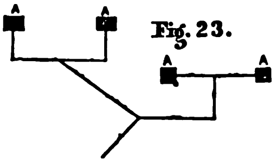


Fig. 23.

Fig 23. Plan of Train for firing the Four Charges at A.

than on the other, the principal trough should be placed 3 in. nearer to the charge on that side, which is done by placing it 1½ in. from the central point towards that side. Square elbows impede somewhat more than oblique ones.

Experience has shown that two trains may be placed within 18 in. of one another if covered with earth, and exploded separately without interference.

24. **Tamping.**—Mines are tamped either with earth and sods; with earth and wood; or with sand bags.

To tamp a branch with sods and earth, the miner first fills the branch with sods for a length of 3 ft., commencing at the chamber. The sods are piled in regular layers, the precaution being taken to throw loose earth over each layer, to fill the voids between the sods. When this length is finished the miner fills in for an additional 3 ft. with earth, which should be well packed. Another length of sods is laid of 3 ft., and so alternately through the entire branch.

To tamp with wood and earth, a stout shield of thick boards is first placed across the branch and firmly buttressed against the chamber, the branch is then filled with well packed earth, resting against the shield, for a length of 3 feet; billets of round or square timber are then packed across the branch for a length, likewise, of 3 ft.; another length of earth of the same thickness is packed in against the wood, and so on for the entire length to be tamped; finally, at the end of the tamping another shield is set up and firmly buttressed.

Sand-bags for tamping are of the ordinary dimensions. To tamp with them a shield is first placed against the chamber and well buttressed. The branch is then filled up with sand bags

been recommended, but are found not to answer. The rocket is then placed in the end of the trough, the quick-match with which it is provided is lighted, and the rocket starts with very great velocity, penetrates the charge and fires it.

Fig. 25.

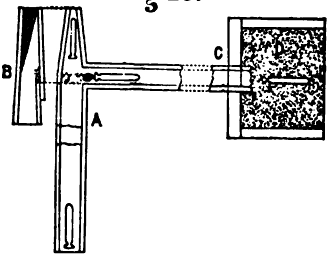


Fig. 25. Plan A of Rocket-Trough, showing Elbow Connexion C with Charge D. B, Section of Trough at the end.

When the rocket has to pass elbows, or when it is desired to fire several mines at the same moment, a rocket is placed at each turn of the trough, with its quick-match secured round a nail: the first rocket arriving at the point where the other is placed, fires it. In order the better to insure the first rocket firing the second, a quantity of powder (¼ ounce) should be scattered about the match of the latter, protected by a wedge-shaped slip of deal, nailed to the bottom of the trough; the rocket meeting this passes over the powder, which its rapid motion would otherwise disperse.

A rocket may be made to turn in a circular trough, when the radius of that part is not less than twice the length of the rocket.

In order to prevent the smoke of the charge penetrating the gallery through the trough, one or two small iron traps may be placed in the trough, which, being raised by the rocket, fall again by their own weight, and cut off all communication between the gallery and the charge.

A rocket 6 in. long will travel 100 yds. at least, and its velocity is so great, that two rockets fired at the same moment, to run very different distances, leave no perceptible interval in the times of their arrival. This property of rockets renders it easy to proportion the trains of mines to be fired simultaneously, which with powder-hose requires great nicety.

The ordinary rocket for this service contains ¾ of an ounce of

To fire the train, place the box against the extremity of the tamping and secure it well; tie a string to the slide and lead it along the stanchions of the gallery on pegs driven for that purpose; put the end of the hose into the box through the hole left for it, and spread on the top of it some dry, fine powder; then put in the slide and close with earth, or rags of sand-bags, all communication between the lower part of the box and the branch; place a star-match of six or eight points, well lighted, on the slide; replace the cover, then pull the string and the star will fall below and fire the mine.

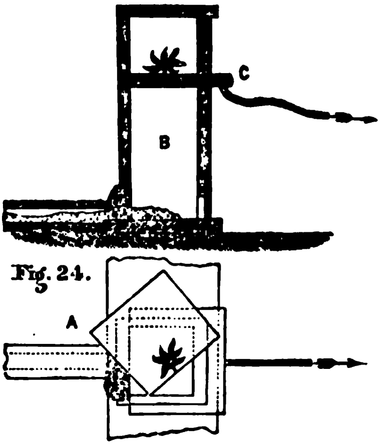


Fig. 24.

Fig. 24. Plan A and Section B of Box Trap. C, Slide attached to Cord.

The two methods above described have the inconvenience of requiring a powder-hose, which, from its own explosion, poisons the galleries. They have also, and more particularly the monk, the defect of not producing the explosion always at the instant desired.

To avoid these inconveniences a galvanic current has of late been applied to fire mines, and with complete success. This method has been found particularly serviceable in firing charges under water.

26. Rocket.—A small rocket (Fig. 25), with a hemispherical head of wood, has also been tried successfully. To use it, a wooden trough with a smooth interior must be placed from the charge to the point where the rocket is to start; tin tubes have

been recommended, but are found not to answer. The rocket is then placed in the end of the trough, the quick-match with which it is provided is lighted, and the rocket starts with very great velocity, penetrates the charge and fires it.

Fig. 25.

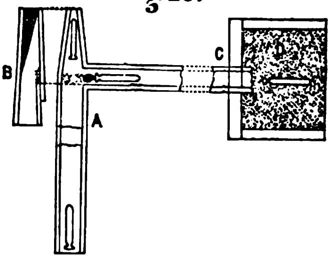


Fig. 25. Plan A of Rocket-Trough, showing Elbow Connexion C with Charge D. B, Section of Trough at the end.

When the rocket has to pass elbows, or when it is desired to fire several mines at the same moment, a rocket is placed at each turn of the trough, with its quick-match secured round a nail: the first rocket arriving at the point where the other is placed, fires it. In order the better to insure the first rocket firing the second, a quantity of powder (¼ ounce) should be scattered about the match of the latter, protected by a wedge-shaped slip of deal, nailed to the bottom of the trough; the rocket meeting this passes over the powder, which its rapid motion would otherwise disperse.

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A rocket 6 in. long will travel 100 yds. at least, and its velocity is so great, that two rockets fired at the same moment, to run very different distances, leave no perceptible interval in the times of their arrival. This property of rockets renders it easy to proportion the trains of mines to be fired simultaneously, which with powder-hose requires great nicety.

The ordinary rocket for this service contains ¾ of an ounce of

a composition formed ⅖ of fine powder, ⅖ saltpetre, and ⅕ of charcoal dust. These ingredients should be very carefully mixed, to make the rocket burn uniformly. Its usual diameter is nearly ¾ of an inch, and entire weight about 1½ ounce. Rockets may be made much smaller when required.

27. Galvanic Battery. The great advantages offered by galvanic batteries for exploding mines at considerable distances from the battery, either when isolated or combined in groups for simultaneous effects, have led to experiments which, from the uniform certainty of the results, besides other obvious advantages over any of the other methods above given, will probably cause the general adoption of this apparatus for military mines.

The method mostly adopted by the Continental engineers is the combination of *Bunsen's* battery with *Ruhmkorf's* apparatus for intensifying the current of induction. A copper conducting wire, which is insulated by one or two coats of gutta-percha, connects the charges with the galvanic apparatus. The charge is exploded by passing a spark through a very small portion of fulminate of mercury inserted between the ends of two copper wires, which are enclosed within a short tube of gutta-percha, coated within with sulphuret of copper. The wires are bent near the end of the tube and twisted around each other. A little meal powder is thrown around the fulminate and the tube, which, with the tube and the bent part of the wire, is tightly closed in a small gutta-percha bag, to keep out moisture. To fire a single mine, one end of the twist is soldered to the conducting wire and the other inserted into the earth to complete the circle. For several mines, to be exploded at the same time, conducting wires connect the mines, and the ends of the twist are soldered one to each conductor, except the end one, which has one of its ends inserted into the earth. By this combination the series will be exploded without any sensible difference of time between the nearest and furthest mine.

28. Blasts. Blasts are small chambers or holes made in rock or masonry, charged with powder. The forming of blast-holes requires the use of particular tools, called *borers*, *jumpers*, *scrapers*, *needles*, and *tamping-bars*.

To form the blast-hole, two or three men are required; one holds the borer with both hands, while the head of it is struck

been recommended, but are found not to answer. The rocket is then placed in the end of the trough, the quick-match with which it is provided is lighted, and the rocket starts with very great velocity, penetrates the charge and fires it.

Fig. 25.

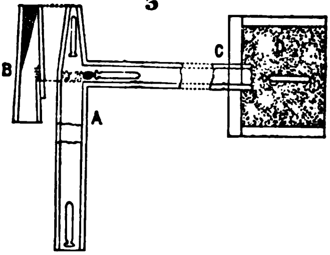

Fig. 25. Plan A of Rocket-Trough, showing Elbow Connexion C with Charge D. B, Section of Trough at the end.

When the rocket has to pass elbows, or when it is desired to fire several mines at the same moment, a rocket is placed at each turn of the trough, with its quick-match secured round a nail: the first rocket arriving at the point where the other is placed, fires it. In order the better to insure the first rocket firing the second, a quantity of powder (¼ ounce) should be scattered about the match of the latter, protected by a wedge-shaped slip of deal, nailed to the bottom of the trough; the rocket meeting this passes over the powder, which its rapid motion would otherwise disperse.

A rocket may be made to turn in a circular trough, when the radius of that part is not less than twice the length of the rocket.

In order to prevent the smoke of the charge penetrating the gallery through the trough, one or two small iron traps may be placed in the trough, which, being raised by the rocket, fall again by their own weight, and cut off all communication between the gallery and the charge.

A rocket 6 in. long will travel 100 yds. at least, and its velocity is so great, that two rockets fired at the same moment, to run very different distances, leave no perceptible interval in the times of their arrival. This property of rockets renders it easy to proportion the trains of mines to be fired simultaneously, which with powder-hose requires great nicety.

The ordinary rocket for this service contains ¾ of an ounce of

a composition formed $\frac{2}{5}$ of fine powder, $\frac{2}{5}$ saltpetre, and $\frac{1}{5}$ of charcoal dust. These ingredients should be very carefully mixed, to make the rocket burn uniformly. Its usual diameter is nearly $\frac{3}{4}$ of an inch, and entire weight about $1\frac{1}{2}$ ounce. Rockets may be made much smaller when required.

27. Galvanic Battery. The great advantages offered by galvanic batteries for exploding mines at considerable distances from the battery, either when isolated or combined in groups for simultaneous effects, have led to experiments which, from the uniform certainty of the results, besides other obvious advantages over any of the other methods above given, will probably cause the general adoption of this apparatus for military mines.

The method mostly adopted by the Continental engineers is the combination of *Bunsen's* battery with *Ruhmkorf's* apparatus for intensifying the current of induction. A copper conducting wire, which is insulated by one or two coats of gutta-percha, connects the charges with the galvanic apparatus. The charge is exploded by passing a spark through a very small portion of fulminate of mercury inserted between the ends of two copper wires, which are enclosed within a short tube of gutta-percha, coated within with sulphuret of copper. The wires are bent near the end of the tube and twisted around each other. A little meal powder is thrown around the fulminate and the tube, which, with the tube and the bent part of the wire, is tightly closed in a small gutta-percha bag, to keep out moisture. To fire a single mine, one end of the twist is soldered to the conducting wire and the other inserted into the earth to complete the circle. For several mines, to be exploded at the same time, conducting wires connect the mines, and the ends of the twist are soldered one to each conductor, except the end one, which has one of its ends inserted into the earth. By this combination the series will be exploded without any sensible difference of time between the nearest and furthest mine.

28. Blasts. Blasts are small chambers or holes made in rock or masonry, charged with powder. The forming of blast-holes requires the use of particular tools, called *borers*, *jumpers*, *scrapers*, *needles*, and *tamping-bars*.

To form the blast-hole, two or three men are required; one holds the borer with both hands, while the head of it is struck with sledge-hammers by one or two others. The first turns the borer at each stroke so that the hole may be circular, and from time to time clears it out with the scraper.

When the hole required does not exceed 15 inches in depth, it may be excavated in the above manner; but if 20 in., or more, deep, the jumper is generally made use of. The miner holds the jumper in both hands, raises it, and lets it fall in the hole, turning it continually; he also clears the hole with the scraper. When the stone is of a very hard description, it is usual to pour water occasionally into the jumper-hole.

To load the hole, fill about one-fourth or one-third of it with powder, according to the nature of the stone. The charge for a depth of 18 inches is from 8 to 12 ounces.

To tamp and prime the blast-hole, the needle is first introduced, plunging it well into the powder and placing it on the smoothest side of the hole; then a layer of clay is laid on the powder, and is closely pressed down with the tamping-bar.

Other similar layers are then laid, or layers of brick reduced to small bits, the needle being turned repeatedly. It is usual to press down the first layers with a bar of wood, the helve of a tool, for instance, and the latter ones with the iron tamping-bar. When the hole is thus filled up, a small shell of clay is formed round the needle, which is then withdrawn, the hole left by it is filled with fine powder, and it is fired with a monk or a piece of port-fire.

The use of the needle is often dispensed with, in which case the priming is rolled up in a sheet of brown paper, or it is introduced in straw-stalks thrust into one another. This priming is placed in the hole at the same time as the charge, so that it may penetrate well into the latter. The tamping is then executed as before.

The use of the tamping-bar and the ordinary tamping may also be dispensed with, the hole being filled over the charge with very fine dry sand, poured in without any pressure.

The many accidents that have happened in priming blasts have led to the invention of priming-fuses, which are made to burn somewhat in the same way as the fuse in the small Chinese fire-cracker. Their use is far safer than any of the former methods.

For blasts under water, the charge is inserted in a water-tight tin case and fired either by a galvanic current or a priming fuse, which is protected from the water by a small tube connected with the charge, and leading to the surface of the water.

The result of many experiments has shown that in blasting rock a large portion of the powder—nearly half—may be saved, by mixing with the remaining part fine, dry saw-dust of elm or beech. In blasts exploded in this way, the effect is not the same as when the full charge of powder is used; the rock splits into fewer and larger pieces, and to finish dividing them a more frequent use of the sledge-hammer is required.

29. Demolitions. The charges of mines intended to demolish masonry, are calculated as in a common soil, by using the proper quantities given in the preceding table.

It is seldom, however, that in field operations the engineer is called upon to do more than to blow up a bridge or destroy an ordinary enclosure-wall, and for this purpose he resorts to the most expeditious means, supplying by increased charges the want of the usual mine-chambers and tamping.

30. Walls. To destroy ordinary walls from 2 to 3 ft. in thickness, one or two barrels placed at the foot of the wall, or better still, if there is time for it, placed in chambers as low as the level of the foundations, and exploded without further preparation, will effect the object.

When the wall is from 5 to 9 feet thick, chambers should be made under the foundations, near the centres of them, and each charged with a barrel of powder, the charges being connected by trains, to have them explode simultaneously.

When the wall is from 9 to 12 feet, if the mortar can be easily picked out so as to remove the stones or brick of which it is built, a branch may be run to the centre of it, and a chamber for a large charge made at its end below its level, the branch being roughly tamped before exploding the mine. In some cases blasts may be used, in others the charges may be placed under the foundations. The question in each case is one, of the time at the disposal of the officer charged with the duty, and the means he has at hand.

31. Houses. In the demolition of houses and powder magazines, the speediest method is to place several kegs of powder with connecting trains along the weakest portions of the walls, to buttress the roof or upper floor against heavy timber laid over the kegs; then barricade strongly from within all the doors and windows, firing the charges by a train led to some distance outside of the building.

32. Bridges. In the demolition of stone or brick bridges, charges may be placed either in chambers made in the faces of the piers, like those for destroying walls, or shafts may be sunk to the arches, between their crown and springing lines, at the bottom of which chambers may be made for the charges. In the first case for piers, from 4 to 6 ft. thick, two chambers, each to contain from 130 to 160 lbs. of powder, may be made in the face of one of the piers, and be connected by a powder-hose which is led to the top of the bridge and to some safe distance along it to where the train is to be fired. In piers, from 6 to 10 feet, like chambers, with charges from 200 to 250 lbs. each, will be required. In the second case the chambers should contain from 400 to 600 lbs. of powder, and, if there is time, be tamped and covered over with all the heavy material that can be piled above them.

In weak arches a trench made along the crown and charged with powder, or several kegs placed under the arch on a board suspended under it and exploded in the open air, will produce the desired effect. Wooden bridges may be destroyed in the same manner.

The officer charged with such operations should remember that it will be best to be profuse of his powder, as a complete success is the essential point.

33. Palisades. To destroy palisades, gates, doors, etc., the best method is to suspend a leathern bag filled with powder, either with a forked stick, a strong gimlet, or a stout copper nail, against the gate or palisade. The bag should have about an inch of port-fire firmly secured in one side of it, to communicate the fire to the charge. To throw down a strong palisade, from 30 to 50 lbs. of powder should be used. To burst open a town gate, 60 or 70 lbs. of powder will be required.

34. Fougasses. Mines are so called when placed at the bottom of small shafts from 9 to 12 ft. deep. The powder is lodged in one of the sides of the shaft, and it is fired from a secure spot by means of a powder-hose train, brought up one side of the shaft, and carried in a trough, parallel to the ground, 5 or 6 ft. below the surface. When there is no occasion to fear that shells may fall on the part where the trough is laid, it will be sufficient to place it 2 or 2½ ft. under the ground. The powder-case and trough should be well pitched, the shaft tamped in the strongest manner, and the earth round about the shaft be dug over, that nothing may indicate to the enemy the position of the fougasse.

35. Shell Fougasses. Shells may be buried singly, or in small heaps, and be made to burst either under the ground, or on its surface.

If they are to burst under the earth, they must be sufficiently charged to produce a crater, through which the pieces are projected.

If they are to burst on the surface, the requisite quantity of powder to produce a crater and throw out the shells must be lodged under them, while these latter need only have a sufficient charge to burst them.

In all cases a box is used (Fig. 26), divided into two parts by a partition. The shells are placed in the upper part; their fuses project through the partition, and extend from ½ to 1 inch below it.

In the lower part, the hose only is placed when the shells are intended to produce their own crater; but powder sufficient to produce the crater is introduced when they are intended to burst on the surface of the ground.

The effects produced by common and shell fougasses are very limited, and only destructive near to their craters, consequently they should not be exploded until the enemy is above them.

Fig. 26.

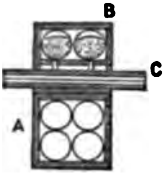

Fig. 26. Plan A and Section B of Fougasse of four Shells. C, Section of Train.

The following table gives the charges and craters of loaded shells for fougasses:

DESCRIPTION OF SHELL.	FULL CHARGE OF THE SHELL.		DEPTH AT WHICH THE FULL CHARGE PRODUCES A CRATER.	
	lbs.	oz.		
Calibre, 5⅘	1	0	2′	0″
" 8	2	9	2	10
" 10	5	0	3	6
" 13	11	0	4	7

CHAPTER III.

CONDITIONS TO BE SATISFIED IN ARRANGING A SYSTEM OF MINES.

It is but rare that, in the defensive arrangements of a field work, any combination for a war of mining is provided for; although in many, and those but recent cases of a stubborn and protracted defence of field works against regular siege operations, mines have been employed with great success, although not made before the works of the assailant were well under way. As the end to be attained is the same in conducting the defence of a work by mines, whether it be a temporary or a permanent one, the same principles in the arrangement of a combination of mines for this purpose are equally applicable to the two cases; the most essential of which are as follows:

36. Galleries. As the galleries of a system of mines serve the purpose of underground communication, they should be subjected to the same conditions as other communications. A condition of primary importance is, that no combination shall be made which might compromise the safety of the work. To this end, no gallery beyond the ditch should lead to the interior of the work; for should the enemy get possession of such a gallery he might either penetrate into the work, or else barricade the gallery and hold possession of it long enough to blow up the works under which it leads.

The galleries should not offer any facilities to the besiegers for carrying on their works. Those galleries, therefore, which, communicating with the ditches, might serve the besiegers for their descent of the ditch; also a continued counterscarp gallery, which may not only facilitate the descent of the ditch to the besiegers, but also, when in their possession, give them that of the whole system of mines, and, besides, serve to protect their passage of the ditch, and to prevent sorties in it, should be rejected. A gallery behind a portion of the counterscarp not favorable to the enemy's works, is very useful as a depôt for the implements of the miners, and also as a communication.

A complex system of mines should not be used for works that can be carried by storm; for the reason that the besiegers might easily get possession of the system before it could be brought into play.

The entrance to a system from the ditch must be revetted, to offer a sufficient obstacle to prevent the enemy from getting possession of the system by surprise; hence, a revetted counterscarp is a necessary condition in the establishment of the system.

The galleries should not be run out to any considerable distance beyond the covered-ways, both on account of procuring a good circulation of air, and because very advanced galleries are easily destroyed by the besiegers. The distance to which the galleries may extend should be so much the less as the ground above them is well protected by the collateral defences.

The soil must be suitable for the establishment of a system; wet, marshy ground, shifting sand, and hard rock, present almost insuperable obstacles; whereas a dry, firm soil, soft rock, or ordinary earth, under a thin superstratum of hard rock, are very favorable circumstances. If the sub-soil is wet, but presents a firm and dry superstratum 12 ft. thick above the level at which the water collects, mines may still be placed with advantage.

Besides the above general conditions, there are certain special ones to be attended to in arranging the galleries and chambers.

The galleries should be placed as far below the surface as practicable, to withdraw them from the effect of the globes of compression of the besiegers. To drain the galleries they should have a slight inclination, about $\frac{1}{15}$, towards the ditches; or, if the ground descends towards a hollow, the inclination may be given in that direction.

The chambers, on the contrary, should be near the surface; by this arrangement the powder is economized, and all danger to the galleries from the explosion avoided, whilst the object of the mines, which is to destroy the enemy's works, can be as fully attained by small mines as large ones.

The galleries should not be placed nearer to each other than twice the line of least resistance of the heaviest charged mines, and not much less than four times the line of least resistance of the smallest charges. This arrangement will admit of a combination of mines in two tiers, the line of least resistance of the lower being double that of the upper, the chambers of which may be so arranged that the explosions of one tier shall not affect either the galleries or the mines of the other. Twice the line of least resistance of the largest mines is the least distance that can be allowed between the galleries, in order that the mines of the lowest tier, which, being placed near one gallery to destroy a part of it, shall not injure those parallel to it. By placing the galleries at this least distance apart, the branches for the service of the upper tier will be as short as possible, effecting thus a saving of time and labor; and for the same reason, the galleries on any one point being as many as can be placed, there will be less chance of all being destroyed by an explosion, but that some one of the galleries will be found serviceable.

The galleries and branches for the service of the different groups of mines should be independent of each other, so that there may be no confusion in the service, and that no group may be rendered unserviceable by the destruction of the communications to another. The same principle should be attended to in combining the different groups of mine chambers.

The galleries and branches should never present their flanks or sides to the globes of compression of the besiegers. This rule leads to the rejection of enveloping galleries.

37. System of Countermines. The systems of countermines proposed by most writers on this branch of the defence are generally of too complicated a character to admit of being executed at a reasonable cost, and they require for their service not only a large amount of powder but also a great number of miners.

The following arrangement, based on the general conditions just laid down, has been proposed, to meet in a simple and satisfactory manner the requisites of a subterranean defence:

Parallel to the capital of an assailable salient of the work, four listening galleries may run out to a distance from 50 to 80 yards beyond the salient; the interval between these galleries being twice the line of least resistance of the heaviest charged mines. If we take this line at 7 yds., or 21 ft., which is about the greatest for common mines, the interval of the galleries will be 15 yds. The dimensions of the listening galleries for about the first 20 yds. may be those of a grand gallery, and the remaining part may be a common gallery. These galleries will depart from a transversal grand gallery about 6 yds. in advance of the counterscarp at the salient, which will serve as a communication between them, and also as a depôt. Other transversals of the size of half galleries, or branches, will be made at different intervals for the purpose of ventilation. This group of galleries will have their outlet into the ditch, through two galleries, one leading from each extremity of the transversal grand gallery. To flank this group, other listening galleries may extend obliquely outwards from the two outside parallel galleries. To serve the mines of this group, a series of ascending branches may lead from the galleries to chambers, placed midway between the galleries, and having a line of least resistance of 4 yds. This will place these chambers at about 8 yds. from the two adjacent galleries. Smaller branches may lead, if necessary, from these last branches to other groups of chambers having a line of least resistance of 2 or 3 yds. A series of chambers with lines of least resistance of 7 yds. will be established in juxtaposition with each listening gallery. From this arrangement it will be readily seen that ground over the mines can be entirely broken up, and that the successive explosions of the mines of one group will destroy the branches and galleries which lead to them, without injuring those of other groups. The object of this disposition is to blow up by repeated explosions the ground over which the enemy must approach upon the assailed salient.

Groups of galleries and mines similar to the one in advance of the salient may be arranged for the defence of the interior of the work at the salient.

As the air in the galleries of mines is liable to become foul from various causes, some mechanical contrivances and chemical methods by which the vitiated air can be removed and fresh air introduced, have to be resorted to for the purpose of enabling the miners to circulate through them with safety. Air-pumps, bellows, and artificial drafts, procured by kindling a fire at one of the outlets of a system of galleries, are the ordinary expedients by which this object is attained.

The great pecuniary outlay requisite in establishing a system of galleries, the time and labor for their construction, besides the large corps of experienced miners and the extra provision of powder demanded for their efficient service when the system embraces any considerable extent of surface, has led engineers to consider whether the end proposed by subterranean means of defence might not be attained by some more simple expedients. Since the application of galvanic currents to exploding mines, and the facilities which it affords to effect this at very considerable distances, it has been proposed to substitute isolated shafts for galleries, placing them in positions most suitable to attain the besieger's works. The shafts, to give them a character of permanency, may be lined with masonry and receive a stone or iron cover, which may be concealed from view by placing it several feet below the surface. When wanted for service, the shafts are charged and tamped in the usual manner, and connected with a galvanic battery by insulated wire conductors, laid sufficiently far below the surface of the ground to be without the sphere of the besieger's excavations, and of other accidents.

CHAPTER IV.

EXAMPLES OF REMARKABLE MILITARY MINING OPERATIONS.

SIEGE OF SCHWEIDNITZ IN 1762.

THIS siege was remarkable for the successful employment of overcharged mines, or globes of compression, in attacking a system of countermines, and for the difficulties which seem to be inherent in the latter in conducting a subterranean defence.

The Prussians, who were the assailing party, having reached, by their trenches, to within about 100 yards of the covered way, drove a gallery in the direction of the salient angle of the work attacked. When this gallery had been driven about 90 feet, the enemy made a sortie, drove off the few guards in the trench, entered and partially destroyed the gallery. The damage done was soon repaired, and the gallery pushed on a foot or two further, when, the air becoming foul, it was decided to charge and fire it. It was charged with about 5,500 lbs. and then tamped and exploded, producing a crater of about 85 feet diameter and 18 feet deep.

After several attempts to push forward a new gallery from this crater, in which the besiegers met with failures, from water making in it, and from the effects of the enemy's countermines, a gallery was commenced from the crater of a countermine which had been prematurely exploded. This gallery, after some delay from the enemy's countermines, was pushed forward about 46 feet; charged with 2,600 lbs. of powder; tamped and fired; producing a crater of 63 feet in diameter and 16 feet deep.

Several attempts made to drive a gallery from this crater were frustrated by the countermines of the besieged. The besiegers finally succeeded in driving a gallery a distance of 21 feet, which was loaded with nearly 4,000 lbs. of powder, quickly tamped and exploded; producing a crater of 63 feet in diameter and 17 feet deep; bringing the besiegers within about 10 feet of the crest of the covered way.

New galleries were commenced from this crater which were soon destroyed, partly by the countermines, and partly by a sortie of the besieged. After some unsuccessful attempts to connect the two last craters, owing partly to the fouling of the air in the gallery, from the explosion of some countermines, a gallery was driven forwards about 100 feet; charged with 5,500 lbs. of powder; tamped; and although two countermines, one on each side of the gallery, were sprung, it was not seriously damaged, and the mine was successfully exploded. The effect of this charge was very great; for, although it did not injure the scarp of the work, it threw over into the ditch a mound of earth, which, resting against the scarp, reached as high as the superior slope of the parapet, affording a practicable ascent. Still, with this advantage, the assaults of the besiegers were met with so warm a fire that they were kept at bay during the night. But a capitulation took place the following morning, after a siege of 63 days, 48 of which were employed in the mining operations.

From the narrative of this siege it would seem that the besieged did not avail themselves sufficiently of the opportunities presented to them for sorties; as the besiegers pushed forward their works without sufficiently guarding them, and from a weak front. Although well provided beforehand with galleries, by which the attempts of the besiegers could be thoroughly watched and met, still the besieged, from the fouling of their galleries, owing to the explosion of their countermines, and from the injury done to their galleries, were unable to defeat the object of the besiegers, who succeeded in pushing forward their attack in the direction selected.

SIEGES OF SILISTRIA AND BRAILOW.

In their attacks, both upon the field and more permanent works of the Turks, as in the sieges of Silistria and Brailow in 1828–29, the Russians resorted to mining to open breaches in each place, and with successful results. Their galleries were driven from their lodgments on the glacis of the works, under the main ditch, to a sufficient distance in rear of the scarp walls, and near their foundations, to establish several globes of compression parallel to and behind the wall. Branch galleries were also run behind the counterscarp walls, and globes of compression established to blow them in. At the siege of Brailow, the Turks made no attempts to counteract the Russians by countermining; and in that of Silistria, the year after, their efforts at it were little more than abortions. In both cases, however, they excavated deep cunettes along their main ditch, to obstruct the Russian approaches. These had no other effect than to force the Russians to sink their galleries lower, to pass underneath the cunette; whilst they subsequently converted it into a good lodgment in the main ditch. The result in each case was, that large practicable breaches were opened by the explosion of the mines, which led to a capitulation.

SIEGE OF SEBASTOPOL.

In this celebrated siege the Russians conducted their underground operations with the same vigor as they showed in their works on the surface. The ground itself was peculiarly favorable to countermining, presenting alternate layers of hard limestone-rock and clay, which enabled the Russians to establish their lowest tier of galleries and mines from between 50 and 60 feet below the surface, thus giving them the decisive advantage, in a subterranean war, of burrowing below their opponents' position. The system of mines which they adopted was a series of listening galleries, running out perpendicular to the counterscarps of the points defended by them; those towards the salients spreading outwards in fan-shape. The listening galleries were connected by frequent transversals. The total developments of the whole combination were about 6,500 yards. On a plan of them, given by the French engineers, it would seem that the Russian miners had not been directed with intelligence, as many of their galleries were run in a false direction, and could not have been used without injuring each other. The most of their mines were undercharged, but they presented a considerable obstacle, and occasioned much delay to the approaches of the French on the points which they defended.

As shown in (Fig. 27) their system of mines, in advance of the salient of the Bastion No. 4, designated by the French as *le Bastion du Mât*, were opened from the bottom of the ditch of this work, by sinking shafts and constructing irregular ramps, which were sheltered from vertical fire by weak bomb-proofs of timber and earth. Some of their galleries, at their entrances, were roughly timbered, as well as the branches of their mines at their extremities. The rest were simply excavations through the natural soil. Light ladders placed in vertical shafts, and ramps, led from one stage to another. For ventilating, they used small double-barrelled air-pumps, and tubes of thin sheet-iron about 2.5 inches in diameter and from 5 to 6 long, which were fitted end to end in each other. They also used india-rubber hose of the same diameter as the sheet-iron tubes. Their chambers were charged by depositing the powder in bags, kegs, or powder-cases. Their tamping was done with sand bags; shields of scantling being placed at every 6 feet, for the half of the branches nearest the chamber, and every 10 feet for the remainder. The shields were buttressed by a strut firmly embedded in the earth to the rear. The tamping was uniformly equal to twice the line of least resistance, and executed with great care; the spaces between the sand bags being crammed with rags.

The mines were fired by electricity, Volta's pile being used for the purpose; the conducting wire being composed of three copper wires covered with gutta-percha.

Looking forward to being compelled to evacuate the works on which the approaches of the Allies were made, and to abandon Sebastopol, the Russians had mined all of their important magazines and works on the south side of the harbor. These mines were connected by conducting cables and fired from the north side of the harbor. The destructive effects were complete; fortunately for the Allies, two of their principal points of attack, the Malakoff and the Redan, were saved by the discovery of the connecting cables leading to the mines which had been prepared under them, and were to have been exploded simultaneously with the others.

The charges found by the French in the unexploded chambers of the upper tier of the Russian mines varied from about 100 to 400 lbs.; being mostly under charges, and amounting, in many cases, to simple camouflets. The French attribute their own trifling losses to these small charges, and state that much larger charges might have been used by the Russians without damaging their own works, whilst they would have produced serious annoyance and loss to the French, by the fragments of rock which would have been thrown among their troops.

The French commenced their offensive mining operations by sinking two shafts, in the reverse of their third parallel, opposite Bastion No. 4; chiefly with a view of sounding the ground preparatory to establishing a few globes of compression, which were to have been discharged at the moment of assaulting this bastion, so as to create confusion among the Russians. The first step was taken on Nov. 20, 1854, and having led to an underground warfare, for the Russians had prepared for it beforehand, the struggle was kept up with unabating skill, vigor, pertinacity, and boldness on both sides, until Sept. 8, 1855, when the final assault was made by the Allies on the Russian works.

The French, as has been stated, had to work under far more unfavorable circumstances than the Russians; the system of countermines of the latter being well ventilated by shafts sunk in the ditch of Bastion No. 4, and others in the glacis, and also, being below strata of a hard limestone rock, and the French, moreover, having a greater distance to push their galleries to reach the Russian countermines than these were from their defensive works in their rear.

With these disadvantages, the French resolved, about March 14, 1855, to break up sufficient ground between their third parallel and the ditch of Bastion No. 4, by a connected series of mines, to give them front enough for a fourth parallel, which was to contain troops to cover their further mining operations. All of their subsequent mining labors on this point, up to the close of the siege, tended to this object; and at this period the effect of their arduous labors is shown in (Figs. 27, 28).

During this time they executed about 100 feet of ramps and shafts, and about 4,000 feet of galleries and branches. They exploded six under-charged mines and camouflets; twenty stone fougasses; thirty-five over-charged mines; and sixty-four over-charged shafts; making a total of one hundred and twenty-five explosions; using in all about 130,000 lbs. of powder. Their losses in killed, in wounded, from momentary suffocations, and in those rescued after having been buried alive, among their own miners and some auxiliary force from the infantry of the line, were two hundred and twenty-eight in all; of which eight were officers, killed either in the mines or trenches by explosions, and eight by the Russian fire.

Not only did the French use their mines to gain a footing for their fourth parallel, but they were obliged to resort to the same means to open, in the rock, communications between these two parallels.

Fig. 27.

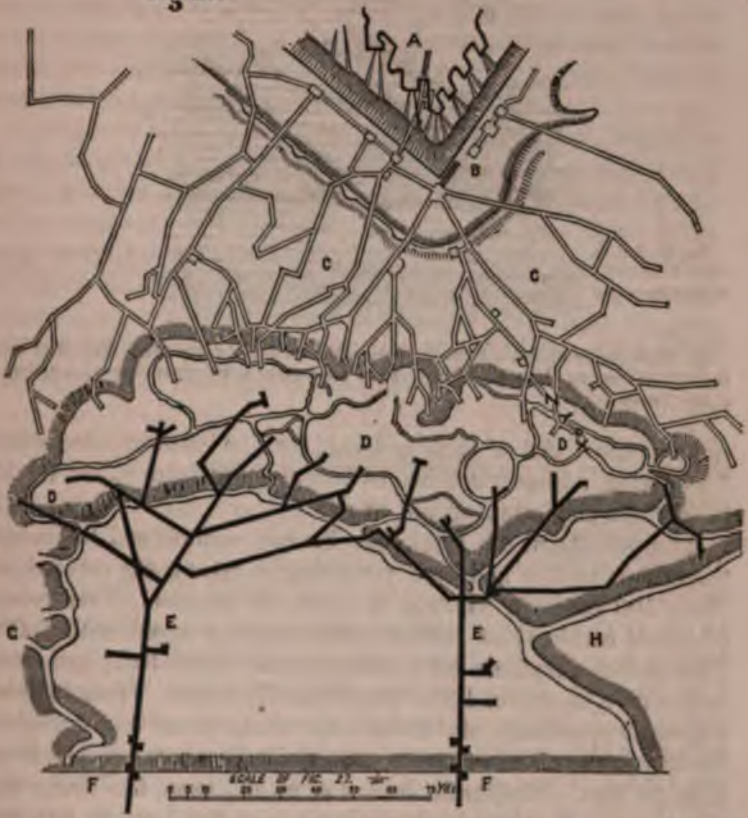

Fig. 27. Plan of French attack and Russian Countermine in front of Bastion No. 4, Sebastopol. A, Salient of Bastion; B, bottom of ditch and entrance to countermines C, C; D, D, Crater formed by explosions of French and Russian mines; E, E, French galleries of attack; F, third Parallel from which French attack was made; G and H, communications between third Parallel and French trenches in and around the borders of Crater D, D, D.

In the journal of their mining operations, the French have given but few practical details. These probably differed but little from the practice of their schools. Working in the thin strata of clay between the beds of limestone, their galleries, for the most part, required to be timbered only on the sides. Their branches were mostly run without being timbered; and they increased their cross-section to 4 feet 8 inches, by 3 feet; having found that, in smaller branches, the air could not be kept sufficiently pure. All of their galleries, for like reasons, were made 5 feet wide, and as much height was given to them as the thickness of the clay strata would allow.

Fig. 28.

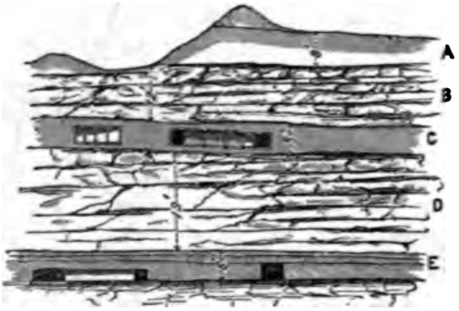

Fig. 28. Section of Ground and Russian countermines on lines X Y, Fig. 27; A, Stratum of clay and soft limestone; C, E, Strata of clay in which the Russian galleries were driven; B, D, Strata of hard limestone.

At noon, April 11, 1855, the French commenced to charge the chambers they had been preparing to open a 4th parallel, at about 100 yards in advance of their 3d parallel. This group of mines consisted of six chambers, each charged with 4,180 lbs.; eleven chambers each charged with 2,508 lbs.; and four each with a charge of 1,254 lbs.; total, 57,684 lbs. To save time, an empty space was left behind each charge; and the branches leading to the chambers were tamped for distances varying from 6 to 20 feet. Bickford's fuse was mostly used for firing the charges. A fuse being attached to one of the bags of powder, each of which contained about 40 lbs., with which the chamber was loaded, it was led along the bottom of the branch to a box, into the side of which as many holes were bored as the number of fuses common to the group of mines; the ends of the fuses were inserted through these holes into 4 lbs. of powder placed in the box. But the better to guard against failure, an ordinary powder hose, placed in a hose trough, led from each mine into a powder box, through which all the fuses likewise passed.

This group of mines was fired at nightfall, April 16. It made but little noise from the explosion, but produced a considerable concussion, throwing the earth and fragments of the rock up to a great height. The craters presented the appearance of a large ravine, but a portion of the ground remained unbroken, thus interrupting the communication between the right portion, which was the most accessible, and that on the left, which afforded the best cover. Otherwise the craters afforded good cover from the Russian fire.

Owing to the rocky character of the soil and the heavy fire of the Russians, no attempt was made to connect the craters with the 3d parallel until the night of April 16, shells being thrown in the meanwhile into the craters, to prevent their being occupied by the Russians; two communications were made, and the craters of the right and left connected by the full sap, on the nights of April 17 and 18, under frequent delays from the Russian fire, as well as with considerable loss of life among the officers and men of the sappers and miners.

SIEGE OF PETERSBURGH.

Report of Lieut. Col. PLEASANTS, *48th Reg. Penn. Vols., on the Construction and Explosion of the Mine before Petersburgh, Virginia.* (Figs. 29, 30, 31, 32.)

This mine was commenced June 25th, 1864, at 12 M., and progressed rapidly till July 2d, when extremely wet ground was reached, which caused the ceiling of the gallery to give way. The soil at this point was a wet marl of the consistence of putty, causing slow progress in the work. To avoid this, an ascending gallery (Fig. 30), rising 13.5 feet in 100 feet, or one foot to 7.4 feet, was driven. The main gallery (Figs. 29, 30), was completed July 17th; the total length 510.8 feet. Operations were now suspended until July 18th, from apprehensions of the enemy's countermining, when two galleries were driven, one to the left of the main gallery, the other to the right, which last, to avoid the attempts of the enemy, who could be heard working above it, was deflected backwards in a curved form, to bring it exterior to the enemy's intrenchments on the surface. The left lateral gallery, which was 37 feet in length, was terminated at midnight, July 22; and the right lateral, 38 feet in length, was

Fig. 30.

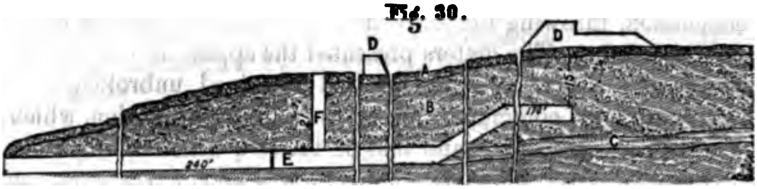

Fig. 30. Section along main Gallery E and Shaft F; A, thin stratum of sandy soil; B, strata of clay and sand; C, thin layer of wet marl; D, D, enemy's works.

Fig. 29.

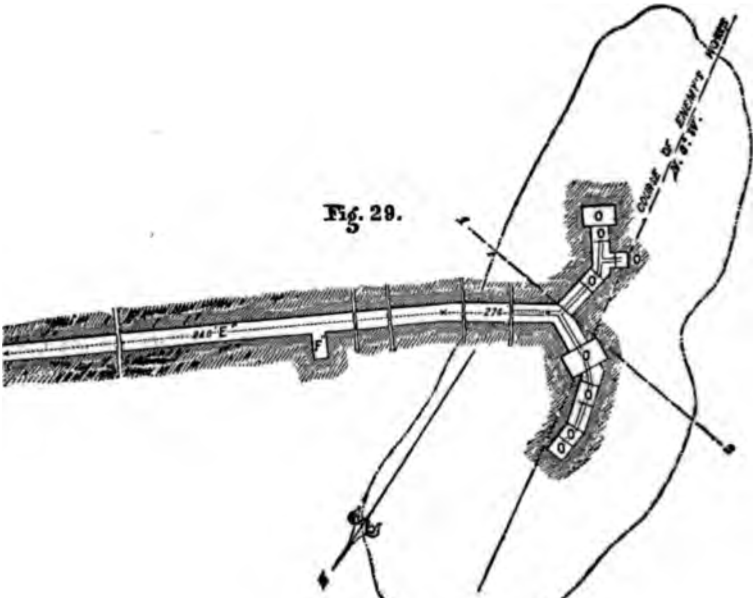

Fig. 29. Plan of Gallery and Mines. E', Gallery; F, Shaft; O, O, O, Mine Chambers.

Fig. 31.

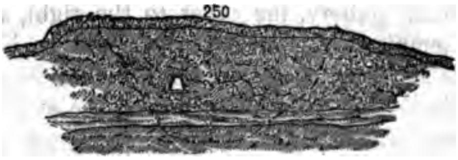

Fig. 31. Section of Crater along the line 1-2. Fig. 29. The dotted lines on the two Figs. mark the outlines of the crater.

terminated at 6 P.M., July 23. From this time to July 27, was employed in draining and placing the powder cases. The cases were filled with powder July 27, between 4 P.M. and 6 P.M.; and the tamping begun at 6 P.M. of this day, and completed at 6 P.M., July 28. The tamping of the lateral galleries extended forward 10 feet from their entrance, and that of the main gallery 34 feet back. No tamping was placed in between the powder cases. The fuse for firing the charges was lighted at 3¼ A.M., July 29th, but, owing to the stoppage of the ignition at a point where the fuses had been spliced, the mine was not exploded until a quarter to 6 A.M.

Fig. 32.

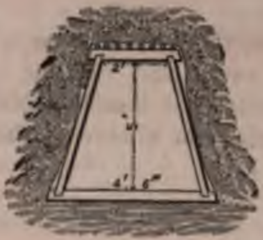

Fig. 32. Cross Section of timbering of Main Gallery.

The charge consisted of 320 kegs of powder of 25 lbs. each, or about 8,000 lbs. This was distributed among the six cases, which were connected by hose troughs about half filled with powder. The troughs united at the junction of the main and lateral galleries. From this point, to a distance of 98 feet along the gallery, three lines of fuses were laid. To gain the requisite length it was necessary to splice the fuses.

The mine was ventilated, at first, by having the fresh air go in along the main gallery and return, with all the gases liberated, in a square tube made of boards; its area of cross section being 60 inches. This tube led to a perpendicular shaft, 22 feet high, out of which the vitiated air escaped. A grating was placed at the bottom of the shaft, on which a fire was built, to rarify the air and increase the velocity of the upward current. The fresh air was led in this way to the end of the gallery, and the foul air to the shaft, through which it escaped; a partition having been placed across the main gallery to prevent its exit through the mouth of the gallery.

As the excavation of the gallery progressed, the number of the working party was increased, and numbered in the end nearly 400 men. The total amount excavated was 18,000 cubic feet. The crater was 200 feet long, 50 feet wide, and 25 feet deep.

An eye-witness of this explosion says, that the enemy fled from their adjacent works, and, for some time, seemed as if paralysed; leaving practically a breach of 500 yards in their lines for our assault, which, from whatever cause, when made, unfortunately failed.

SIEGE OF VICKSBURG.

From the commanding position of the defensive works of this place over the trenches when advanced to within a short distance of the ditches, and the means of annoyance by hand grenades, and even 6 and 12-pdr. shells thrown over on the heads of the sap, a resort to mining was had upon several points to open breaches in the parapet, and in each case the mines were exploded with complete success, although the mining operations were undertaken without the aid of a thoroughly trained military mining corps, such men among the troops as had been engaged in coal mining having been employed on the occasion. There are no peculiar features of interest in these operations, further than the aptitude shown by our troops for any work to which they may be put in devising a means from whatever may be found at hand. The galleries were framed and secured very much in the same way as the one used at Petersburg. The charges were mostly small, the lines of least resistance not exceeding some 28 feet. The attempts made by the assailed at countermining did but little damage, and retarded but slightly the progress of the besieging operations.

SIEGE OPERATIONS.

ATTACK BY REGULAR APPROACHES.

CHAPTER I.

TRENCH MATERIALS AND TRENCHES.

1. The term *Regular Approaches* is applied to the means employed by a besieging force to reduce a fortified position which is too strong to be carried by the usual mode of an open assault.

These means consist in approaching the position under the cover of the ordinary trench bordered by a parapet, which is gradually pushed forward in the most favorable directions to shelter the troops placed in it from both enfilading and plunging fires.

2. In the construction of the trenches various articles are required to give speedy and safe cover, besides the usual trenching tools. These are termed *Trench Materials*, and consist of—1. *Tracing Tape or Cord;* 2. *Tracing Pickets;* 3. *Ordinary Pickets;* 4. *Fascines;* 5. *Sap Fagots;* 4. *Gabions;* 5. *Sap-Rollers;* 6. *Sand-Bags;* 7. *Blindage Frames;* 8. *Gallery Frames* and *Sheeting.*

Tracing-Tape or Cord.—This is a strong white tape or cord usually 150 feet long, and divided off into spaces of 6 feet, a piece of tape 6 inches in length being sewed to each point of division. At each end of the tracing-tape a short piece of cord is attached to tie the tape to two tracing-pickets. The tracing-tape, for convenience, is rolled up into a ball.

Tracing-Pickets.—These are 18 inches long and one inch in diameter. For ordinary use they are tied up in bundles with their bark on; but for setting out night work the bark should be stripped off to make them more readily seen.

Ordinary Pickets.—Those used for securing fascines are from 2′ to 4′ long, and from 1¼″ to 1¾″ thick; those for setting out or tracing the works are 18″ long and 1″ diameter.

Fascines.—These are usually made 18′ long, and 9″ in diameter, and are afterwards cut into suitable lengths for the purposes to which they are to be applied.

Sap-Fagots.—These are made, like fascines, of straight brush wood at least 1″ in diameter. They are 2′ 9″ long, and 5″ in diameter. The centre stake should be from 1½″ to 2″ in diameter, and project 9″ beyond one end of the sap-fagot; this projecting portion is sharpened, to enable the sap-fagot to be planted firmly in the ground in an upright position.

Gabions.—The exterior diameter of these is 2′, and the height of wattling 2′ 9″. They are made with seven, or nine stakes, which project 6″ above the wattling at top, and are pointed.

The ordinary trench gabion and the gabion for revetting batteries receive the same dimensions; the latter is more strongly made and of the heaviest brush wood.

At the siege of Sebastopol the want of brush wood for the wattling of gabions led to the introduction of the common hoop-iron for this purpose, which had served to secure the bales of hay. The number of pickets employed for each gabion was usually thirteen. It was found that these gabions could be constructed more readily than the ordinary kind; that they were not much heavier, were more durable and in all respects as serviceable. Since then it has been proposed to use simple sheet iron cylinders of suitable dimensions instead of the brush wood gabion. For this purpose rectangular sheets of iron, of suitable dimensions to form cylinders of the same height and diameter as the ordinary gabion, are prepared with three or four holes punched near and parallel to the shorter sides of the sheet, to secure these ends with wire when the sheet is bent into the cylindrical shape. Besides these, two other holes of larger size are punched towards the central portion of the sheet, so as to be diametrically opposite when the cylinder is formed, to receive a picket passed through them which serves as a handle in carrying the gabion. The advantages of this description of gabion are greater strength, lightness and durability than either of the others; offering great facility for distant transportation, and resisting better the blast of guns when used for revetting the cheeks of embrasures. To prevent the iron from rusting readily it has been proposed to galvanize the plates. This end could perhaps be better subserved by treating them, as we now do our hollow projectiles, to a coat of mineral tar laid on hot.

Sap-Rollers. This is a large gabion 7 feet 6 inches in length, and 4 feet 4 inches exterior diameter. It requires for its construction fifteen stakes, each from 1½ inches to 2 inches in diameter. After it is completed, it is stuffed compactly with fascines 7 feet 6 inches long. The sap-roller is sometimes made of two concentric gabions, the diameter of the smaller 2 feet 6 inches. The space between the two is compactly stuffed with fascines.

Sand-Bags. The sand-bag, for the revetment of batteries, when empty and laid flat, is 2 feet 8 inches long, and 1 foot 4 inches wide; those used in the construction of the trenches are 2 feet long and 12 inches wide.

3. Trenches. Trenches are divided into two principal classes; *approaches* or *boyaux*, and *parallels.*

4. Approaches. The approaches serve simply as covered communications which lead to and connect the parallels, and are usually directed towards the points of the defences upon which the attack of the besiegers is made. The approaches are run in a zigzag, or in a straight line, towards one or several of these points. The trenches of the approaches (Figs. 7, 8) are 8 feet wide at bottom; 3 feet 6 inches deep in front, and 4 feet at the rear. The reverse receives a slope of 45°. The front is usually made with a slope of 2 feet base.

The earth from the trench is thrown to the front to form a parapet. The general height of this parapet is nearly 5 feet; its width at the base about 18 feet.

5. Parallels. The parallels are designed as stations for troops to guard the besiegers' works and the workmen employed in their execution from the sorties of the garrison. The general direction of the parallels is parallel to, or concentric with a line connecting the most salient points of that portion of the defences attacked. The trenches of the parallels (Figs. 3, 4, 5, 6) receive a width at bottom of 10 feet; their depth in front is 3 feet, and in rear, 3 feet 6 inches. Two steps, each 18 inches high and 18 wide, lead from the bottom of the trench, on the front side, to the natural ground. The reverse of the trench receives a slope of 45°; or else, is also cut into two steps. The steps in front are alone revetted with fascines.

6. Simple Trench. When the parapet is formed of earth alone (Figs. 1, 2), the trench is termed a *Simple Trench.* In this case the earth of the parapet is allowed to take its natural slope on the side towards the trench. The step, or berm of 18 inches between the foot of the parapet and the trench in the parallels, serves as a banquette.

Fig. 1.

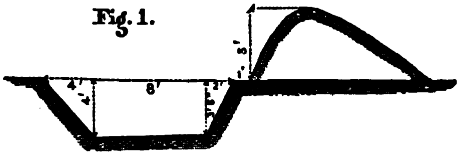

Fig. 1. Profile of Approach by the Simple Trench.

Fig. 2.

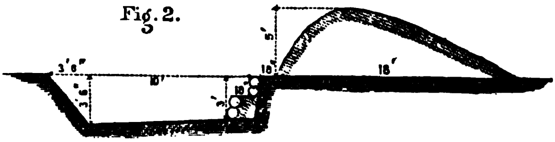

Fig. 2. Profile of Parallel formed of a Simple Trench.

Portions of the parallels (Fig. 3), from 20 to 30 yards in length, are arranged with steps, revetted with fascines, leading from the trench over the parapet, to enable the troops in the parallel to move from it to repel a sortie of the besieged.

Fig. 3.

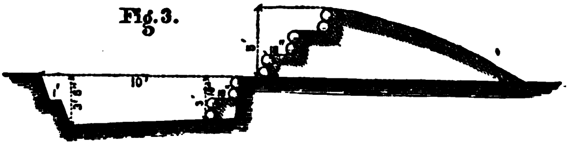

Fig. 3. Profile of a Parallel of a Simple Trench with Steps for Sorties.

The direction of the simple trench is laid out by the tracing-tape and pickets. The trench is executed by soldiers of the line; each man being furnished with a pick and shovel, with which he places himself speedily under cover, by digging a hole and throwing the earth in front of him; continuing his labor until he has excavated 6 feet in length of the trench, and as much of it to the rear as may be assigned to the relief, or working party, to which he belongs. After the trench has received its general width and depth, the slopes and steps are finished off under the direction of the engineer troops.

7. Flying Sap. When the trenches have been pushed forward to within destructive range of case shot, the construction by the simple trench has to be abandoned, and one which will afford more speedy shelter resorted to. This is effected (Figs. 4, 5, 6), by placing a row of ordinary gabions in juxtaposition, along the direction of the trench; these being filled with the earth from the trench, the parapet is completed by throwing the remaining earth over and beyond them. This process is termed the flying sap, from the rapidity with which the work is done. It, also, is executed by troops of the line, each man bringing two gabions on the ground, which he is required to fill, and also to complete the portion of the trench, in the rear of them, assigned to the relief to which he belongs. The requisite height is given to the parapet either by heaping up the earth above the top of the gabions, or by placing three ordinary fascines upon

Fig. 4.

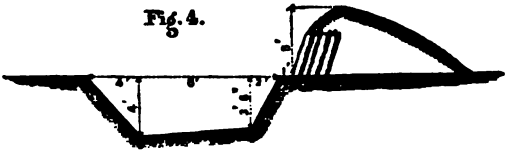

Fig. 4. Profile of Approach by the Flying Sap.

Fig. 5.

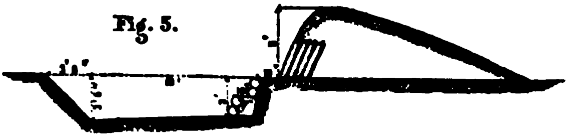

Fig. 5. Section of Parallel with Flying Sap.

Fig. 6.

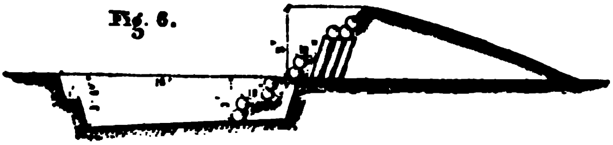

Fig. 6. Section of Parallel with Steps for Sorties.

the gabions, two being in the bottom course and the other on top, and throwing up the earth at least as high as the top fascine.

In positions where the earth cannot be obtained in sufficient quantity to afford a speedy cover, as in a shallow stratum of soil on rock, etc., two rows of gabions, placed in juxtaposition, may be used for the flying sap.

The troops for constructing both this and the simple trench are divided into three parties or reliefs. The first digs the trench to the requisite depth and to the width of 5 feet. The second widens it 4 feet 6 inches. The third finishes what remains, giving the requisite slopes to the front and rear.

Remark. The dimensions and forms given to the profiles of the parallels and boyaux in the preceding paragraphs are those used in our own and the English sapper practice. The French allow usually 3 feet 3 inches for the uniform depths of both and 4 feet 3 inches for the height of parapet. This gives a cover of 7 feet 6 inches in the trench. The greater penetration of the projectiles of rifled guns at long ranges, would seem to favor giving greater depth to the trenches and greater thickness to their parapets to obtain more secure cover. It has been proposed, therefore, to make the trenches 5 feet deep, and without changing the height of the parapet to increase its thickness. At the Siege of Sebastopol the trenches were made, in some cases, 6 feet deep.

8. Full Sap. The full sap (Figs. 7, 8, 9) is resorted to when the fire becomes so destructive that the flying sap cannot be used. The trench is opened and pushed forward by engineer troops alone; for this purpose a working party, termed a *brigade*, of eight sappers is requisite. The brigade is divided into two equal *sections;* the sappers of the first section dig the trench, and are numbered from 1 to 4; No. 1 leading. The other four are termed *assistants;* they bring forward the materials, and assist the first section in all the necessary operations.

The leading sapper, No. 1, is provided with a pick and shovel, and wears a musket-proof helmet and cuirass; he works on his knees, being covered, on his side toward the defences, by the parapet of the trench, from which he débouches; and in front by a sap-roller, which is placed perpendicular to the line of direction on which he is to work, and rests against the gabion he is filling, covering it one foot. The portion of the sap which he digs is 21 inches wide at top and 21 inches deep; it receives a slope of 4 perpendicular to 1 base on the front, and is vertical in the rear; and its length is 5 feet. So soon as this portion is

Fig. 8.

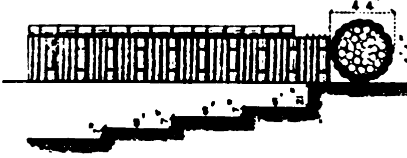

Fig. 9.

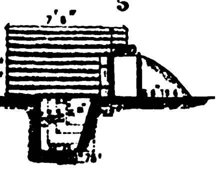

Fig. 7.

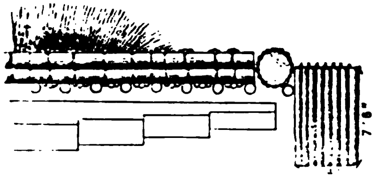

Fig. 7. Plan. Fig. 8. Longitudinal Section. Fig. 9. Cross-Section of Full Sap.

finished, No. 2, who is protected in all respects like No. 1, commences to widen and deepen the trench 8 inches at the point from which No. 1 started, and follows on after No. 1, keeping always 5 feet in his rear. When No. 2 has pushed forward 5 feet, No. 3 commences and enlarges the trench in each direction 7 inches, he follows on also 5 feet in rear of No. 2, but as the work thrown up by the sappers preceding him affords pretty good cover, he can work standing, taking the precaution to bend forward for greater security. Finally, No. 4 begins when No. 3 has got on 5 feet, and deepens and widens 7 inches. As he is well covered he can work in an unconstrained posture.

Besides the shelter given on the flank by the gabions, as they are successively filled, and by the sap-roller in front, the further precaution is taken of driving sap-fagots along the berm, at the junction of the gabions; these are successively removed as they are no longer requisite. The trench fascines are placed upon the gabions by the assistants; and the remainder of the trench completed by working parties of the line, so soon as the brigade of sappers have proceeded far enough for the others to commence without hindrance.

9. Double Sap. This sap (Figs. 10, 11) consists of two heads of sap pushed forward by two brigades working abreast. Its object is to form a trench in a position exposed to fire in front and on both sides. The head of the sap is covered by two sap-rollers placed end to end; a bag of wool, or a short sap-roller, being placed at their junction, for a screen. The distance between the two rows of gabions is 13 feet. The earth between the two lines of sap is removed by the usual working parties, as in the preceding case.

Fig. 11.

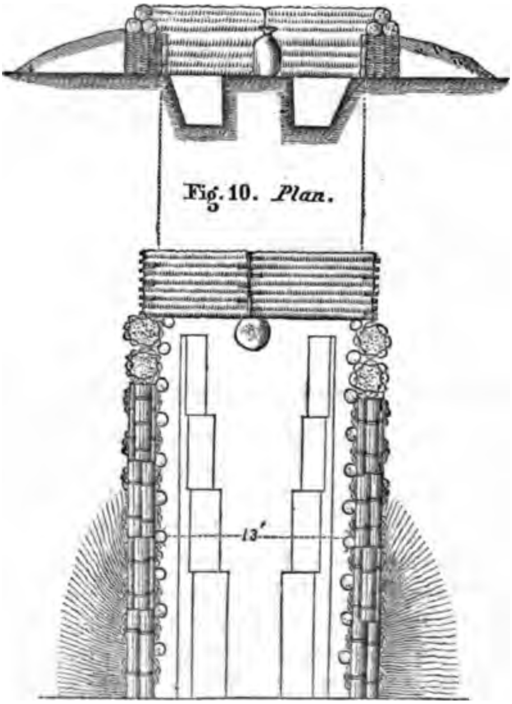

Fig. 10. Plan. Fig. 11. Cross-Section of Double Sap.

10. Half Double Sap. This is an ordinary line of full sap (Fig. 12), pushed forward in a position where it is necessary to give temporary cover on the reverse of the trench, from a slant fire by gabions filled with sand-bags. The distance between the two rows of gabions, in this case, is only 5 feet 6 inches, the single sap-roller covering in front this interval from enfilading fire.

11. Practical Defilement of Approaches. The parallels, from their position, are covered by their parapets from all fire of the besieged; but the boyaux, from receiving a direction towards the besieged works, may be exposed either to a very oblique slant fire in their front; to an enfilading and a slant reverse fire; or to a fire on both flanks and in front. From the first, they are usually secured, by running them out so far beyond the point from which the most dangerous slant fire may come, that a projectile, thrown from this point, striking the top of the parapet of the boyaux, will not plunge low enough to hit a man standing at the reverse of the trench and in the line of direction of the fire. This position is attained, in practice, on a site sensibly horizontal, by giving the line of the trench such a direction, that prolonged it would pass 30 or 40 yards outside of the most dangerous point. On ground inclining downwards towards the dangerous point the direction given should be the further out as the exposed ground is the steeper; but, on ground rising towards the dangerous point, the direction may be laid nearer in towards the dangerous point than on sensibly level ground, so as, in some cases, to be run directly upon this point, with full security from its fire. In practical field operations, the selection of the proper direction in each case will depend upon the experience of the engineer conducting the approach, and his *coup d'œil* for the lay of ground.

Fig. 12.

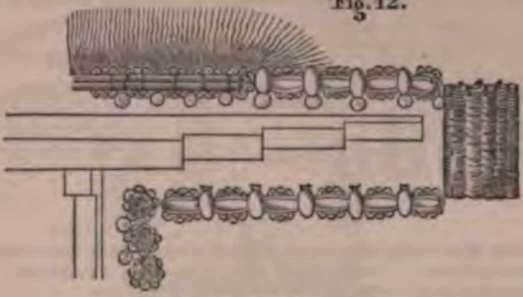

Fig. 12. Plan of Half Double Sap.

12. Where the approach is exposed to an enfilading and a slant reverse fire, and does not admit of a change of direction to avoid these, resort is had to the erection of traverses across the line of trench to cover from an enfilading view, and to short portions of trench, termed *wing traverses*, run back from the approach in a direction perpendicular to it, the parapets of which intercept the slant fire.

To effect this (Fig. 13), the trench is carried forward by means of the half-double sap. So soon as the head of the sap has been advanced the length of twelve-gabions beyond No. 4, a short end of sap is commenced in a direction perpendicular to that of the trench, and run out until it intercepts the line of fire upon the point of departure of the trench, which should be at most at the distance of twelve gabions in the rear. When this end of sap is completed, the provisional parapet of the trench in its rear can be taken down, and the trench enlarged to its proper width. In this way the trench is successively pushed forward and enlarged, until a position has been reached where it becomes necessary to place a traverse to cover the trench from both enfilading and reverse views. These traverses, A, A, are made by changing the direction of the trench perpendicular to that of the original line, and continuing in this new direction, by the full-sap, the requisite length of the traverse; the original direction is then resumed, and continued, by the half-double sap, a sufficient distance to leave room for the width of the traverse and a trench of double sap; a rectangular return is then made, by the double sap, back to the line of gabions of the original trench, and the original direction is taken up and carried forward by the half-double sap.

Fig. 13.

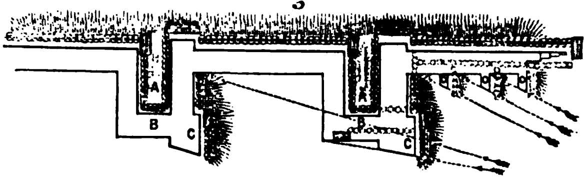

Fig. 13. Plan of Half Double Sap to cover from Enfilading and Slant Reverse Fire. A, A, Traverses for enfilading cover; B, Trench around ends of Traverses; C, Prolongation of Trench to cover B from slant fire; O, O, O, Wing Traverse to cover from slant fire.

The traverses, A, A, are usually seven gabions, or about 14 feet in width. Their length will depend on the position of the dangerous point, but they are seldom made over 30 feet in length. Their distance apart will also depend on the command of the dangerous point. The portion of trench between any two traverses must be perfectly covered by the advanced traverse. As a practical rule the traverses are not placed farther than 25 or 30 yards apart.

The portion of the trench, B, in rear of the end of the traverse is covered by extending sufficiently far to the rear of it an end of trench, C, forming a wing traverse, to intercept the line of slant fire.

13. In the case of an enfilading fire and a fire on both flanks (Fig. 14), the trench A is carried forward by the double sap, until the point of departure, B, is about being exposed to the fire coming in over the sap-rollers; a change of direction, C, at right angles is then made by the full sap, to the right or left, and pushed forward the length of about fifteen gabions, or so far as to intercept any slant fire on either side of the trench in rear, when the original direction, D, is resumed by the double sap. A change of direction is sometimes made by the full sap both to the right and left at right angles to the original line, and pushed to the length of twelve or fourteen gabions each way. Then, from the extremities of these branches, a direction parallel to the original is taken up by the double sap, and pushed on until the point of departure to the rear is about being exposed, when a change of direction towards each other is made at right angles,

Fig. 14.

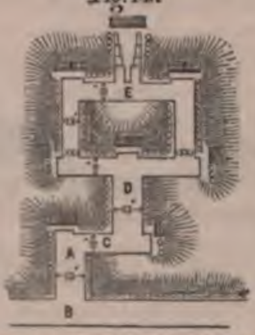

Fig. 14. Plan of a Double Sap exposed to a fire in front and on both flanks. A, D, Double Direct Sap; B, Parallel; C, Full Sap at right angles to gain the direction D; E, Full Sap connecting the two branches of double direct sap on the right and left.

by the full sap, and the two branches are united on the original direction, E, which is resumed by the double sap.

14. Trench Cavalier. This work consists of a parapet raised on a mound of earth for the purpose of obtaining a plunging fire on the covered-way of the besieged work. The mound should in all cases be raised so high that the cavalier will have a command of 4 feet 3 inches over the crest of the covered-way. The position and plan of the cavalier are shown in Fig. 15.

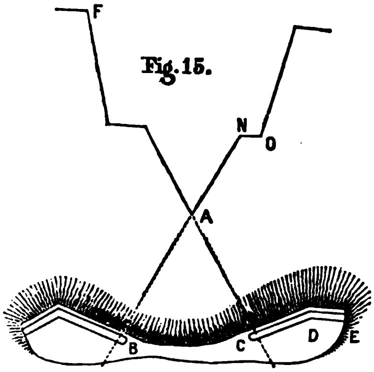

Fig. 15. Plan of Salient of a Covered-Way and Trench Cavalier to command it. A N, Long Crotchet, and N O, Short Crochet of Covered-Way; C D, Long Branch, and D E, Short Branch of Cavalier; B C, Circular Trench.

When the trenches are advanced by the full sap nearly within reach of grenades thrown by hand, or about 30 yards from the salient A of the covered-way, a circular portion of trench, B C, is formed, to embrace the prolongation of the crests of the salient; from the extremities of this circular portion the sap is run perpendicular to the direction of the crests, to a distance, C D, of about 8 or 12 yards, so as to give an enfilading view on the covered-way; at the extremity, D, a *wing* or *return*, D E, is made to cover the part C D from the flank and reverse fire of the collateral works; this part, D E, may, in some cases, be arranged nearly parallel to the crotchets N O of the covered-way, so as to give a fire on them; but, generally, it serves only to cover the branch C D, as has been explained.

15. There are two modes of constructing the cavalier, depending on the nature of the soil. When the excavated earth is of such a nature that it can be easily made to stand at any slope, a

profile represented by Fig. 16 is preferred, as requiring less time and materials. After having laid out the position of the cavalier by the full sap, the sappers widen the trench 6 feet, and make a step at the bottom of the trench 22 inches in height, and 5 feet 6 inches within the gabion of the parapet; this step serves as a platform on which the sappers mount to level the earth of the parapet even with the fascines on top of the first gabion, for the purpose of raising a second tier of gabions, which is placed 22 inches beyond the first. The second tier is filled with earth, and crowned with two fascines, and the mound is raised to a level with the fascines, by widening the trench to the rear. The earth is now levelled even with the top of the fascines, and a third tier of gabions is placed just on the outside of the second; it is filled with earth, crowned with three fascines, and the mound is raised to a level with the upper fascine. This top tier forms the parapet of the work. Loop-holes are made by arranging sand-bags on top of the parapet, for the purpose of covering the heads of the men whilst in the act of firing. As the successive tiers of gabions are placed, steps, revetted with fascines, are made to lead to the top; these steps have a rise and tread of 22 inches; the top one serves as a banquette.

Fig. 16.

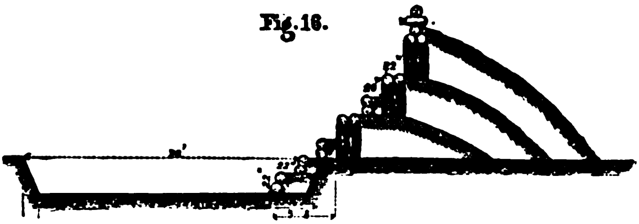

Fig. 16. Section of Trench Cavalier in Stiff Soil.

16. When the soil excavated is loose, a cavalier made in the manner just described would not be sufficiently firm. The following construction will in this case be used. After having traced out the cavalier as before by the full sap, a row of gabions (Fig. 17) is placed in the bottom of the trench, along the foot of the interior slope; this row is filled with earth, and crowned with two fascines, and earth is filled in between it and the interior slope of the trench and brought to a level with the berm. A third tier of gabions is placed on this platform alongside of the row forming the parapet of the trench; this tier is, in like manner, filled with earth and crowned with two fascines. The second tier of the cavalier is commenced, by placing a fourth row of gabions over the joint of the two in the first tier; this is filled with earth, crowned with two fascines, and the mound is raised on the exterior to a level with this fourth gabion. A fifth row is next placed alongside of the two in the first tier, filled with earth and crowned with two fascines. A sixth is then placed alongside of the fourth, in the second tier, and arranged like the preceding. Finally, the parapet is formed on this second tier, by placing a gabion above the joint between those

Fig. 17.

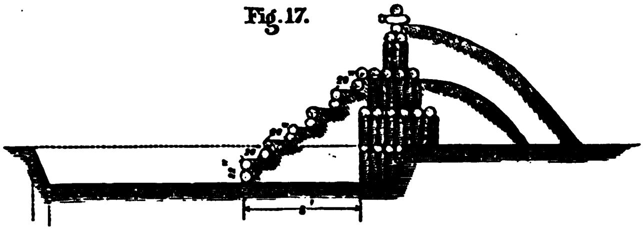

Fig. 17. Section of Trench Cavalier in Loose Soil.

of the second tier, and arranging it as in Fig. 17. The steps are made to ascend to the top, by throwing up a mound of earth, on the interior, against the gabionade, and forming the surface into steps revetted with fascines, as in the last case.

In conducting the operations in both these cases, it will be seen that the top of the mound of earth in rear of the gabions should be preserved on a level of at least a gabion and a half in height below the top of each successive tier of gabions when filled with earth, in order to give the workmen ample cover from the enemy's fire.

CHAPTER II.

COVERED TRENCHES AND PASSAGE OF DITCHES.

17. Blindages. When a trench has to be pushed forward in a position where the command of the dangerous point is so great that it cannot be sheltered from the plunging fire by traverses, it is covered on the top, and on the sides by fascines and earth supported by a framework, and is termed a *Blindage* (Fig. 18).

Fig. 18.

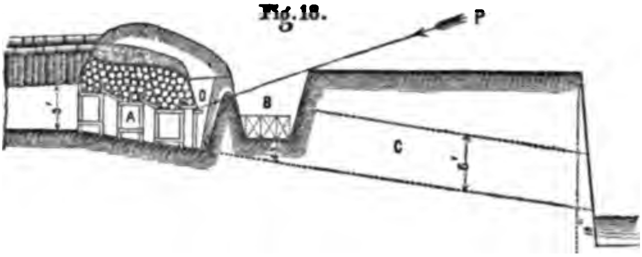

Fig. 18. Longitudinal Section of Blindage Descent into Covered-Way. A, Blindage Frames; B, Covered-Way; C, Gallery Descent to Ditch; O, P, Direction of besieged fire coming over end of Traverse.

18.—The frames used, termed *blindage frames* (Fig. 19), are

Fig. 19.

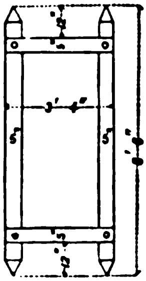

Fig. 19. Side Elevation of Blindage Frame.

composed of two uprights or stanchions of 5 inch scantling, each

8 feet 6 inches long and pointed at both ends; and two horizontal pieces of the same sized scantling each 3 feet 4 inches long. The horizontal pieces are notched upon the stanchions at 12 inches from each end. The width of the frame from out to out is 3 feet 4 inches, the distance between the horizontal pieces from out to out, 6 feet.

An *auxiliary stanchion* (Fig. 20) with a projecting piece is used in placing the blindage-frames.

Fig. 20.

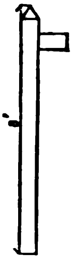

Fig. 20. Side elevation of Auxiliary Frame.

19. This method of obtaining cover is principally requisite in trenches which descend towards the dangerous point; like the passages which lead from the trenches on the glacis into the covered-way, or to the bottoms of shallow ditches. The manner of forming the blindage (Fig. 18), is to set up a row of blindage frames along each side of the trench or passages; to connect the two rows at top by like frames laid across the line of the trench; to cover the top frames by fascines and earth; and to fill in between the side frames and the sides of the trench with fascines. The trench is made by the double sap. Its width at bottom is 7 feet 6 inches. The width between the frames 6 feet. The frames and fascines of the blindage are gradually placed as the trench advances, the latter preceding the former about 5 feet. The work is begun by placing an upright frame on each side; the two are next connected by a frame on top, one side of which is lodged on the top cross pieces of the upright frames, and the other supported by two auxiliary frames until the next two upright frames are placed; the fascines are then thrown over the top frame to the depth of about 2 feet, and these are covered

with earth or raw hides, to prevent their being set on fire. Fascines are at the same time placed in on the sides.

20. The slope given to the bottom of a blinded descent should not be greater than one perpendicular to four base. When the descent is to a covered-way (Fig. 18), the bottom of it should come out in the covered-way at 43 inches below its terre-plein; this will serve to determine the point of departure, the slope being fixed, which should be five feet below the surface of the glacis, so that when the blindage is put up at this point the top of it shall not be above the level of the parapet of the trench. A horizontal landing about 8 feet in breadth is made at the entrance of the blindage; and this is connected with the bottom of the trench by two ramps of one-sixth.

21. The point selected for a blinded descent into a covered-way is usually at the end of a traverse of the covered-way; as the traverse will thus serve to cover the outlet of the blindage into the covered-way from a plunging fire in front.

22. Gallery Descent. A descent to a ditch is usually by blindage when the depth of the ditch does not exceed 10 or 12 feet. For greater depths the commencement of the descent is by a blindage (Fig. 21), which is continued to a point where the bottom of the descent is about 9 feet below the surface of the ground; here the blindage is terminated, and the remainder of the descent is made by gallery, as the depth of the earth above the gallery will be sufficient to allow the excavation to be carried on without trouble. In a firm soil, grand gallery frames are used for the descent; in a loose soil, common gallery frames.

Fig. 21.

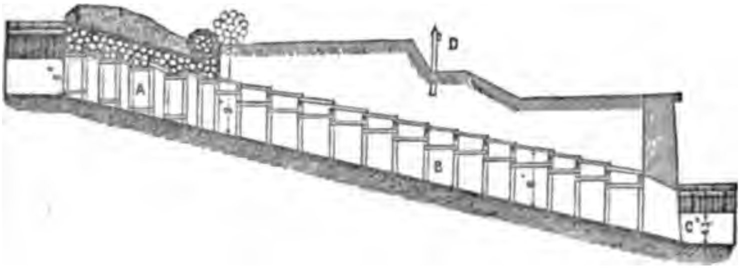

Fig. 21. Longitudinal Section of Blinded and Gallery Descent into ditch. A, Blindage Frames; B, Gallery; C, Passage of ditch; D, Covered-Way.

The frames used and construction of the gallery are the same as for a mine gallery.

22. The point of departure of a ditch descent is usually taken at only about 2 feet below the bottom of the trench; the usual landing being made at this point. In a dry ditch, the bottom of the descent should come out at the usual depth of the full sap below the bottom of the ditch. In a wet ditch it should come out about 15 inches above the water level.

23. **Passage of Dry Ditch.** The passage of a dry ditch is nothing more than a full sap, which leads from the outlet of the descent in the ditch to the bottom of the breach. From this point the trench and parapet are directed up the breach to the scarp wall, which forms the side of the breach towards the dangerous point. The only precaution necessary in making this passage is to sink the trench at the outset to its full depth of 43 inches to gain secure cover.

24. **Passage of Wet Ditch.** The passage of a wet ditch is a perilous and difficult operation under any circumstances, but particularly so when a strong current can be produced, by the besieged, in the ditch. The methods usually recommended are to form a dike, or bridge of fascines and hurdles, laid in successive layers, and firmly connected by pickets. To form a footing for the dike, a grand gallery is excavated, directly behind the counterscarp wall, to a distance of 12 or 15 feet on each side of the descent, and the earth from it is thrown into the ditch, through the outlet of the descent. The dike or bridge of fascines is gradually pushed forward from this point, being secured in the best way practicable to the earth thrown into the ditch. The sappers who carry forward the head of the dike are covered from the fire of the dangerous point by a musket-proof mask of fascines and boards, attached to a raft on which they work. The dike should be from 12 to 15 feet wide at top. A gabionade parapet, formed of two tiers of gabions, filled with earth, is placed on it towards the dangerous side. The bottom tier consists of two rows of gabions each crowned with two fascines, the two rows being in juxtaposition; the top tier is a single row crowned with three fascines. The top of the dike is covered by a layer of earth, and the parapet with raw hides, to prevent the effects of incendiary compositions that might be thrown on them. Raft-bridges, on barrels, protected by a gabionade parapet, have

also been proposed, particularly where a strong current is to be contended with.

25. Splinter Proofs. Shelters of the same kind as those described in Art. 79, *Field Fortification*, were used both for the guards of the trenches and for the men serving the batteries at the sieges of Forts Pulaski and Wagner, and afforded safe and comfortable quarters to the men off duty. These should be placed adjacent to the points where the men are on duty, and in the best sheltered positions from the fire of the besieged.

26. In addition to this kind of splinter proof, which serves as a temporary barrack for troops off duty, portions of the trenches, which are most exposed to the fire of the besieged, could be converted into good shelters, by deepening the trench to 5 feet, and then laying saplings or logs across it from the natural surface, giving them a lean-to against the opposite parapet, and covering them with 3 or 4 feet of earth.

CHAPTER III.

BATTERIES.

27. Enfilading and Counter-Batteries. These batteries are used for destroying the artillery and traverses, and silencing the fire of the defences. Positions are chosen for the enfilading batteries, from which the terre-pleins of the faces and other lines, that bear upon the ground on which the parallels and approaches are laid out, can be swept throughout; the counter-batteries are so placed that they can bring a direct, or a slant fire against the embrasures of the points to be silenced. The shot from the former is thrown with small charges, under small angles of elevation, so as to ricochet along the terre-pleins, taking the guns of the defences in flank; the latter fire with full charges directly against the point to be attained.

28. As the effects of both direct and enfilading fire vary greatly with the range, positions should be chosen for these batteries as near the defences as they can be thrown up without too great a sacrifice of life. Positions which will give ranges between 300 yards and 700 yards are the best for smooth bore guns; nearer than 300 yards the workmen would be exposed both to the fire of musketry and case shot; beyond 700 yards the fire upon the defences becomes very uncertain.

29. The greater range of rifled guns gives to the besiegers a greatly enlarged zone in the choice of positions for enfilading and counter-batteries over that for the ordinary siege train of smooth bore guns. This greater range and the greater certainty of the fire of rifled guns, are more favorable to counter-batteries than to those intended for enfilading; as the great angles of elevation under which the guns are fired, to attain the desired ranges, give to the projectile, in the descending branch of its trajectory, a great plunge, which, although more favorable to attaining objects covered by traverses than if the plunge were smaller, is less favorable to the 'ricochet of the projectile from which the chief advantage of enfilading with round shot is derived. Besides this, the elongated projectiles used in rifled guns from the form given to their point are readily deflected from their course by very slight obstacles, as a fascine even, which also adds to the uncertainty of their effects. At the Siege of Fort Wagner it was observed that the heavy projectiles of the smooth-bore navy guns were landed with more accuracy within the enemy's works, and were more destructive in their ricochet than the projectiles from the army rifled guns.

The judgment and experience of the officer must in these cases be left full play in the selection of the position of the batteries of these two classes of guns and in their armament; bearing always in mind two very important considerations: first, that with long ranges and high angles of elevation the projectiles will clear all the trenches in front up to a near approach of the besieged work without danger to them, except from unforeseen accidents; and second, that to secure any decided or certain effect from either class of these batteries, there must be nothing to obstruct the view of the object to be attained.

30. The batteries may be placed either within the parallels, in advance of, or in rear of them. The positions usually selected are from 20 yards to 30 yards in front of the parallels; because, if placed within them, there might be mutual interference between the service of the batteries and that of the parallels, which is often a very serious cause of delay to both the service of the batteries and the passage of the troops; and, unless placed some distance in the rear of it, the parapet of the parallel might obstruct the shot of the battery, and the troops in the trench be annoyed by the fire.

31. The most effective positions for batteries of smooth-bore guns, are in front of the second parallel of from 300 to 400 yards from the point to be reached; and unless the fire of the defences is very destructive, it will be best to place them there. If placed in front of the first parallel it may be necessary to shift the most of them to the front of the second parallel soon after the latter is thrown up; for the third parallel and the approaches leading to it from the second parallel run the risk of being attained by shot from batteries at so great a distance in their rear as the first parallel.

32.—The site of the platforms of the batteries may either be on the surface of the natural ground, or sunk below it. In the latter case the parapet and epaulments are obtained from the excavation of the site, and the battery is termed a *Sunken Battery.* In the former case the parapet and epaulments are obtained from a ditch in advance of the parapet. In the sunken battery the labor of construction is less, and the men engaged in making it are placed more speedily under cover than in the other kind. Sunken batteries can only be used, however, when the trenches or other elevated points, in advance of the batteries, which lie in their field of fire, will not intercept the shot; and, as a general rule, these batteries should be placed only in positions where their field of fire is completely unobstructed by the trenches.

33. The interior crest of an enfilading battery should be nearly perpendicular to the prolongation of the line to be enfiladed; and be so placed that the shot from all the guns shall sweep the terre-plein throughout its entire length. The position of a battery that will satisfy this last condition can be readily found, as it must evidently lie within the angle formed by producing to the exterior the diagonals of the terre-plein to be swept. The best position of the guns will be to place one so that its line of fire shall be nearly on the prolongation of the interior crest of the line enfiladed, and the remainder on that side of this one by which the terre-plein will be swept throughout and the guns along it be seen by a slant and slightly reverse fire.

34. In a counter-battery, the interior crest should be nearly parallel to the line to be counter-battered. A position somewhat oblique to the line, so that the shot of the battery may enter the embrasures obliquely, is also a good one for tearing away the cheeks of the embrasures, and exposing the guns of the defences.

35. Whenever a position has to be take up for an enfilading or a counter-battery, in which the direction that can be given to the interior crest is very oblique to that which it ought to receive, it will be necessary to make the embrasures of the battery with a corresponding obliquity to the direction of the parapet; but, to avoid the inconvenience of these embrasures when very oblique, it will be necessary to break the interior crest into a serrated line, to allow the muzzles of the guns to be run the requisite distance into the embrasures; placing one side of the indent perpendicular to the axis of the embrasure, and the other parallel to it.

36. Enfilading batteries for ricochet are best armed with smooth-bore 18 and 24-pounders, and 8 inch howitzers. The fire of the guns is mainly directed against the artillery of the defences; that of the howitzers to sweep the covered-ways and ditches, to destroy the palisadings and the traverses by the explosions of the shells that may lodge in them. As a general rule, there need not be more than seven pieces, nor should there usually be less than three in any one battery; the number depending upon the bearing which the artillery of the part to be silenced may have upon the ground on which the works of the besiegers must be placed. The batteries should be as far asunder as practicable, so as not to invite a concentration of the fire of the defences upon any point, by the accumulation of a large number of pieces on it, and thus multiply the chances of loss both to the troops and *matériel.*

37. The greater part of these batteries will occupy fixed positions during the time they are in use, and which, as has been stated, will depend upon the positions occupied by the artillery of the besieged. Other batteries of lighter calibre, which can be easily shifted from point to point, as the exigency may require, can be used in combination with these, by taking advantage of any natural covers, or by throwing up slight parapets like those in ordinary field works. For batteries of rifled guns, with long ranges, the guns may safely and advantageously be placed in barbette. For positions within more certain range of the besieged works, the guns should be placed in embrasures more or less open according to the field of fire desired.

38. In computing the extent of front of a battery, an allowance of 18 feet, estimated along the interior crest, is usually made for each piece, but for guns of heavy calibre, particularly if in barbette with a wide traverse, the distance may be increased to 22 feet; 6 feet are allowed for each splinter-proof gabionade traverse, one of which is placed between every two guns, when there are more than three in a battery. The flanks of the guns are covered by an epaulment thrown up on one, or both extremities, of the parapet. The length of the epaulment, measured along its interior crest, may be from 20 to 30 feet. The direction of the epaulment with respect to the parapet will depend on that of the fire of the defences; as a general rule, its interior crest should make an angle of about 100° with that of the parapet. When the platforms are on the natural surface, the earth for the parapet, epaulments, and traverses is taken from a ditch in front of the parapet and epaulments, and parallel to their respective directions. A narrow ramp, at the end of each epaulment, leads from the natural level to the bottom of the ditch, and serves for the convenience of communication for the men whilst throwing up the battery. A trench, of the ordinary dimensions of an approach, and defiled from dangerous points, leads from the extremities of the epaulments to the parallel in their rear.

39. If the embrasures are so oblique as to require an indented parapet (Fig. 26), the side or face of the indent, through which the embrasure is pierced, should be 22 feet, and perpendicular to the axis of the embrasure. The other side, or *flank* of the indent should be 25 feet, and parallel to the axis; a distance of only 7 feet being left between these two last lines, to give all the thickness practicable to the portion of the merlon that forms the outer angle of the indent; for a like reason the face of the indent, at the extremity of the battery, should extend 21 feet beyond the axis of the embrasure. These *data* will serve to estimate the total length of the parapet. Its thickness, estimated from the inner angles of the indent, is 18 feet.

40. The profile of a battery will depend both for its dimensions and form on the command of the point from which it can be attained, and on the position of the surface of the ground, on which it is laid out, with respect to the defences.

Where the site of the battery is horizontal, and the command of the defences over it is within the usual limits of 20 to 30 feet, the following forms and dimensions (Fig. 22), will afford ample cover to the men and *matériel* of the battery, when the platforms

Fig. 22.

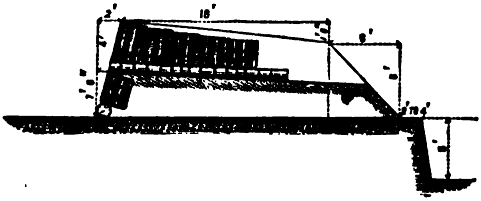

Fig. 22. Section of Enfilading Battery through sole of embrasure, the genouillere and cheeks revetted with gabions and large fascines.

are on a level with the natural surface. Height of interior crest, 7 feet 6 inches. Thickness of parapet, 18 feet. Interior slope, $\frac{4}{1}$. Superior slope, $\frac{1}{12}$. Exterior slope, the natural slope of the earth. The same dimensions and forms may be given to the epaulments, except the distance between their interior and exterior crests, which may be reduced to 12 feet when the direction of the epaulment is quite oblique to that of the fire of the defences. In the contrary case, this distance should be 18 feet. The depth of the ditch is taken at 5 feet; its width will be regulated by the quantity of earth to be furnished for completing all the parts of the battery.

41. The axes of the embrasures (Fig. 23), are 18 to 22 feet apart, except at the points where splinter-proof traverses are placed, the requisite distance at these points being 24 to 28 feet, allowing 6 feet for the width of the base of the traverse. The sill of the embrasure is 3 feet 6 inches above the platform for guns mounted on the ordinary siege carriage; its sole is parallel to the superior slope. The mouth of the embrasure is of a trapezoidal form, being 2 feet wide at bottom and 3 feet at top. The splay of the sole is usually obtained by giving the sides an inclination of $\frac{1}{5}$ with the axis; but when this is insufficient to afford the desired field of fire, the splay may be increased and the axis of the embrasures placed further apart, to give the merlons sufficient thickness. The top line of the cheek is obtained by setting off along the direction of the exterior crest, from the point where the side of the sole cuts it in projection, one-half

Fig. 23.

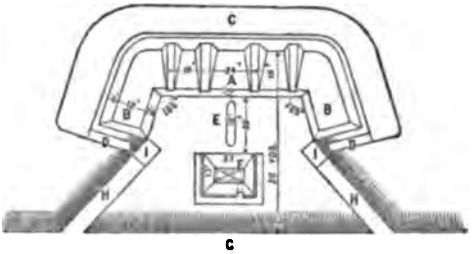

Fig. 23. Plan of Enfilading Battery of four guns. A, Parapet; B, B, Epaulments; C, Ditch; D, Ramps leading to ditch; E, Splinter-proof Traverse; F, Magazine; G, Parallel; H, Boyaux communications to battery; I, Ramps from boyaux to battery.

the vertical distance between these two last lines, and joining the point thus found with the exterior point of the mouth at top.

42. Embrasures of howitzers and guns firing under great angles of elevation may receive a counterslope, giving the sole nearly the same inclination, from the sill upwards, as the least angle of elevation under which it may be required to aim the piece.

43. As the field of fire of a fixed enfilading or counter battery is usually limited to a very short portion of the defensive line, whereas a large portion of the fire of this line can usually be brought to bear on the battery, it will be best to give the narrowest splay to the embrasures, both direct and oblique, not to expose the guns more than absolutely necessary to embrasure shots; leaving to movable batteries the task of keeping down any fire of the besieged concentrated upon the fixed battery.

44. The parapet of the battery and the embrasures are revetted either with gabions, fascines, or sand-bags; or with a combination of these.

Fig.24.

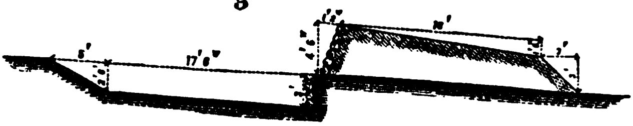

Fig. 24. Section of a Sunken Battery revetted with fascines.

The requisite slope is given to the gabions of the first tier by placing a row of fascines under them, along the foot of the interior slope. Another row of fascines is laid on top of the tier, along the interior slope, on which the gabions of the second tier rest. The requisite height is given to the parapet either by placing sods on the top tier, or by earth alone. When sand-bags are used they are laid in single courses along the interior slope, and as headers and stretchers; the courses breaking joint. To give the bags greater durability they should be impregnated with tar before being filled.

45. It has been found that raw hides will assist in preserving the revetments of the cheeks from the effects of the concussion produced by the firing. For this purpose, the hide is folded with the hair inwards. It is confined to the top of the cheek by

pickets driven through it into the merlon; and at the mouth and the other end of the cheek by pickets driven into the revetment. The lower end is allowed to hang loose.

Fig. 25.

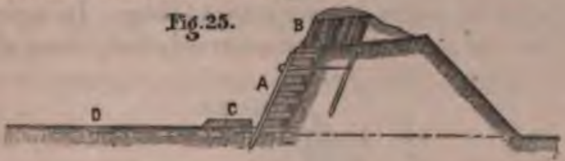

Fig. 25. Section of a Battery at Siege of Fort Wagner, for heavy guns with Counter-Sloping embrasure. A, Interior slope revetted with sand-bags, retained by pickets and anchoring wire; B, Gabion revetment of cheeks; C, Pintle block of carriage; D, Wooden rail for traverse wheels of carriage.

47. The revetment should be adapted to the nature of the soil. In ordinary earth or loam, any of the ordinary kinds of revetment, when carefully put up and well anchored with pickets and withes or strong wire, will stand well in batteries of the heaviest guns. But in loose soil and particularly light dry sand, the only revetments that will hold well are those of sods, sand-bags, and plank. Gabions, fascines, and hurdles are too open to hold soils of this character. Even when sand-bags are used it is well to keep the revetment well moistened to prevent the sand from escaping through rents in the bags. When the sand-bags have been properly anchored, the face of the revetment when worn can be readily repaired by introducing sods.

48. The English have used with success the sheet-iron gabion for revetting the cheeks of their embrasures, as they stand well the blast of the guns which none of the others do, particularly the ordinary gabions, and sand-bags even, when covered with raw hides. At the siege of Fort Wagner (Figs. 26, 27), the soles, throats, and the portions of the interior slope adjacent to

Fig. 26.

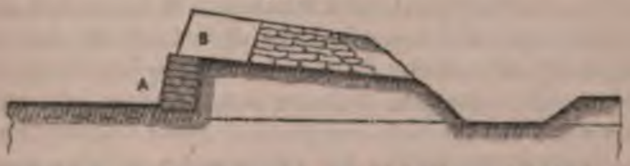

Fig. 26. Section of Battery with parapet A revetted with Sand-bags, and cheeks of embrasures with wrought-iron B for the throat, and sand-bags towards the exterior.

the mouths of the embrasures, were revetted with quarter-inch plates of sheet-iron, to about 4 feet back from the mouth, and 1 foot along the interior slope. These parts were firmly fastened to each other by angle irons riveted to them. In erecting the battery, the sole pieces were first accurately laid; these were then secured to the cheeks and the inner facing pieces; the merlons were then carefully built up with sand-bags and the iron facings anchored firmly into them by means of properly bent rods and iron wire.

Fig. 27.

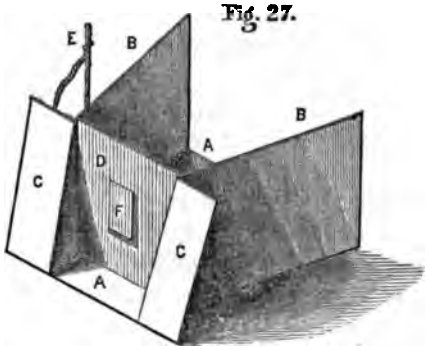

Fig. 27. Isometrical view of Wrought-Iron Casing for throat of embrasure and Door or Mantelet of same. A, Sole piece revetted to Cheek pieces B at the angles; C, Front pieces; D, Door hung on horizontal angle at top; E, Lever with cord attached to pull up the door; F, Slot in the door for rammer.

49. A very simple mantelet of sheet-iron was devised for covering the men whilst in the act of loading and sighting the piece. It consisted of a door hung on a horizontal axle fastened to it near the top, the ends of the axle resting on a hole in each cheek of the embrasure. A lever, which could be inserted into a ring fastened to the door at the bottom, projected above the top of the door and had a cord fastened to its upper end, so that by pulling the cord downward the door could be thrown up horizontally, or with any desired elevation to suit that given to the gun. A rectangular hole, or slot, one foot long and six inches wide, was cut in the centre of the door to allow the rammer to pass whilst loading the gun and for sighting the gun. The door was 2 feet 5 inches high, and 2 feet 2 inches wide; and, when down, hung vertically within the throat, just without the interior crest.

50. The epaulments need not be revetted, their interior slopes being made as steep as the earth will stand at. The gabion revetment, in good soil, is the firmest and most durable of the ordinary revetments. When used for the parapet two tiers will be requisite.

51. The splinter-proof traverses (Fig. 28), are formed of two tiers of gabions. The lower tier consists of two parallel rows of gabions, and is 5 feet wide at the base; the rows of gabions are slightly inclined towards each other at top. The upper tier also consists of two rows, which rest on two rows of fascines, laid on the first tier, the gabions leaning against each other at top. The gabions and the space between them are well filled in with earth, which is heaped above the top-tier. The traverse may be from 15 to 18 feet long. A passage way of 2 feet is left between the parapet of the battery and the end of the traverse.

Fig. 28.

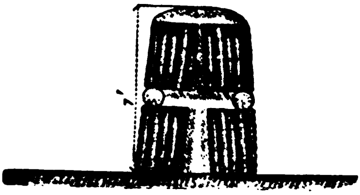

Fig. 28. Section of Splinter-proof Traverse of two gabions in thickness.

52. The platforms are 10 feet 6 inches wide, 15 feet long, in the clear, and receive an upward slope of 7 to 8 inches from the heurter to the tail. They are composed of 5 sleepers, each 15 feet long and 5 inches on the side; of 12 planks, each 10 feet 6 inches long and 2 inches thick; of 2 *ribands*, or *side-rails*, of the dimensions of the sleepers; and of a heurter. The sleepers are firmly imbedded in the ground and secured by stout pickets at their ends. The planks are clamped between the side-rails and outside sleepers, these pieces being connected firmly either by screw-bolts and nuts, or by rack-lashings.

53. In sunken batteries, the same length of interior crest is allowed for each gun as in the preceding case; but when the battery requires splinter-proof traverses, an allowance of 26 or 30 feet is made for the distance between the axes of the guns separated by a traverse. The position and length of the epaulments are also determined as in the preceding case.

54. The trench of the battery (Fig. 26), when first excavated, is 16 feet wide at bottom, 3 feet deep in front, and 2 feet 6 inches deep in rear. The front is cut down vertically in firm soil, and the reverse receives a slope of $\frac{1}{2}$. The interior crest of the parapet is 4 feet 6 inches above the natural surface; the parapet 18 feet thick; the interior slope $\frac{4}{1}$; the exterior slope $\frac{1}{1}$. A berm of 18 inches is left between the parapet and the trench when first excavated.

55. As the dimensions above given to the trench will furnish earth only for the parapet, that required for the epaulment is taken from a ditch 5 feet deep exterior to it; and a small portion of ditch is made exterior to the parapet, and opposite the position of each splinter-proof traverse, to provide the earth requisite for the traverse, and which is taken from the trench.

56. The front of the trench is revetted with fascines. To put up this revetment the trench is widened by cutting away the front, nearly to the width of the berm, and almost vertically. This will admit the muzzles of the guns to be run well into the embrasures.

57. To avoid the labor and expense of revetments, it has been proposed, neither to revet the portion of the trench bordering the epaulment, nor the interior slope of the epaulment; but to leave a berm at this part, 3 feet wide, when the trench is in course of construction, and, afterwards, to give both to this portion of the trench and the interior of the epaulment as great a slope as the earth will stand well under.

58. When splinter-proof traverses are requisite, a portion of the ground 6 feet wide, on which the traverse is to stand, is left. The traverse is made by first placing two parallel rows of fascines at 5 feet apart, on which a tier of gabions, also of two rows, rests; the gabions being so inclined as to touch at top. The gabions and the void space between them are filled with earth, which is heaped up above them to the same level as the interior crest. The sides of the trench bordering the traverse are cut to a suitable slope and revetted with fascines. A passage of 2 feet is left between the gabionade of the traverse and the interior slope of the parapet.

59. To provide against rainy weather, two or more holes

should be dug at such points of the trench of the battery as may be found most convenient to receive the water that collects in the trench; and precautions should be taken to prevent water from being received into the battery trench either through the communications leading to it, or from the natural surface.

Fig. 29.

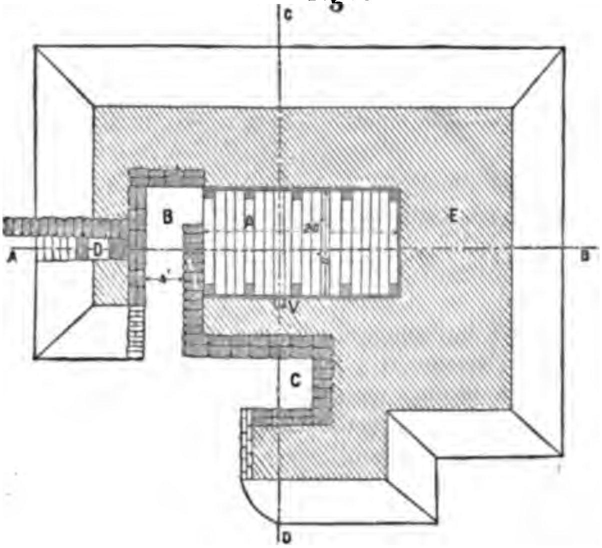

Fig. 29. Plan of Powder Magazine at Siege of Fort Wagner. A, Interior of Magazine; B, Covered entrance; C, Telegraph office; D, Lookout on top; E. Embankment of sand covering the magazine; V, Vent. The plan is taken just below the ceiling.

60. Powder Magazines. The powder magazines are usually placed 30 feet in rear of the parapet of the battery. The ceiling of the magazine should not be more than a few inches above

Fig. 30.

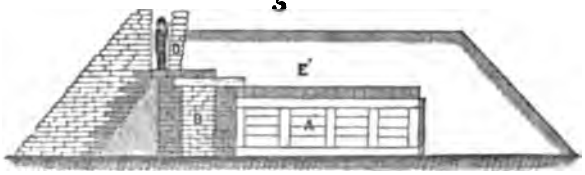

Fig. 30. Section of Magazine on A B, Fig. 29. A', Interior of Magazine; B', Entrance; D', Lookout; E', Covering of sand.

the natural level. The interior height need not be more than 5 feet. The width may be 6 feet, and the length 12 feet in the clear. The sides of the magazine may be formed of frames and sheeting boards; or, of a row of gabions crowned with two courses of fascines. The magazine is covered at top by splinter-proof timbers, 6 by 9 inches, laid in juxtaposition and covered with at least 3 feet of earth, both on top and on the sides towards the parapet. A passage leads into the magazine on the side from the parapet, which is reached by one or two inclined trenches.

Fig.31.

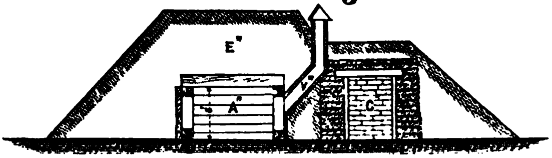

Fig. 81. Section on C D. A'', Interior of magazine; C'', Telegraph office; E'', Sand covering; V'', Vent.

61. To give security from the heavy projectiles of rifled guns, the timbers of the framing and top ceiling of magazines should be from 12 to 15 inches in diameter; and every exposed side be covered with from 6 to 8 feet of good soil. In marshy soils a good bed of brushwood, compactly laid and covered with sand or rammed loam, or else one of two thicknesses of plank, should be used for the frames to rest upon. It would be well, in like cases, to give an inside as well as an outside sealing of planks, closely jointed to prevent the infiltration of water.

62. In view of the loss of life and injury done to batteries by the explosion of magazines, it would probably be better to place them 30 or 40 yards on either flank of the battery, securing them well from the fire of the besieged, and giving them a safe separate trench of communication with the battery.

63. **Mortar Batteries.** There are two kinds of mortar batteries used in the attack: those for mortars throwing shells; and those for mortars throwing baskets of stones, or other like projectiles. Besides these, there is the Coehorn mortar, which, from its small size, may be placed in any unoccupied corner of the trenches within their range from the besieged works. The first kind of batteries may be in front of the first and second paral-

lels, or on any other points farther back. The positions chosen for them should be such as to bring as great a portion of the defences under the direction of their fire as practicable, to increase the chances of destructibility of each shell thrown. The second kind are usually placed in front of the third parallel, mainly with a view to annoy the covered-ways and parts adjacent.

63. The platforms of these batteries may be laid on the natural surface, in which case, the same forms and dimensions will be given to the parapet and epaulments of the battery as in gun batteries; but as the mortars must be set so far back from the parapet as to enable the shell to clear the interior crest by about 3 feet, a revetment will not be necessary, and the parapet may receive as great an interior slope as the earth can be made to stand under firmly.

The front of a mortar battery is estimated, by allowing 15 feet for each mortar, and 6 feet for each splinter-proof traverse.

64. These batteries are usually sunk below the natural surface, since even several feet difference of level in the position of a mortar will have but little effect on the range, or the trajectory. The profile suitable for such positions, under ordinary circumstances, is the following. Width of trench at bottom, 13 feet 6 inches. Depth in front, 3 feet 6 inches. Depth in rear, 4 feet. Reverse slope, $\frac{1}{4}$. Front slope, 2 feet base. Height of parapet, 4 feet. Thickness of parapet, 18 feet. Berm, 1 foot.

The earth for the epaulment is taken from an exterior ditch; and, when splinter-proof traverses are required, portions of ditches are made opposite to their position to furnish the requisite earth.

65. The platforms of mortars are 7 feet 6 inches long, by 6 feet 6 inches wide. They are composed of two ground-sills, 7 feet 6 inches long and 6 inches square; five sleepers, 7 feet 6 inches long and 6 inches square; two side-rails, 7 feet 6 inches long and 4 inches square; eight planks, each 6 feet 6 inches long and 4 inches thick. The ground-sills are laid horizontally, and firmly imbedded in the ground at 4 feet 6 inches apart, and transversely to the sleepers. Upon these the sleepers rest; each being confined by two strong pickets near each end. The planks are confined to the sleepers in the same manner as in gun platforms.

Mortar and other batteries for firing loaded shells, are provided with bomb-proof shelters for the men who load the shells, and others also for the loaded shells. These shelters may be placed in the epaulments of the batteries, under thick traverses, or in any position most convenient for the service of the battery.

66. **Observatories.** For the purpose of observing the flight and effect of the projectiles, a look-out is arranged on one of the flanks of the battery; in most cases the end of an epaulment will afford a safe point, where a secure shelter of sand-bags can be so made as to enable an officer with a field glass to note the range and effect of the fire, so as to regulate it and give the greatest efficiency.

67. **Breach Batteries.** Exposed revetments of masonry may be breached by heavy smooth-bore guns, at ranges from 400 to 600 yards, and batteries thrown up in such cases are in all respects like those for enfilading, or counter-battering.

68. When the revetments are covered from distant fire by an earthen mask, the breach batteries must be placed on the borders of the ditch, either on the glacis, or on the terre-pleins of the defences, at points where no obstruction will intervene to prevent the fire of the guns from being directed at a point of the wall to be opened low enough to form a breach which shall be practicable to the ascent of an assaulting column.

69. The results of the recent sieges of Forts Pulaski and Wagner are conclusive upon the question of the vulnerability of the best masonry to rifled projectiles at long ranges. The former work was breached with 30-pounder rifles at about 1700 yards, and General Gillmore, in his report, expresses the opinion that the best constructed brick revetments can be breached with satisfactory rapidity at ranges of 2,500 yards. The range of the batteries of 8 and 10-inch Parrott guns against Fort Sumter was from 3,500 to over 4,000 yards, from which every vulnerable part of this work that could be reached from the batteries was laid in ruins.

70. The effect of these projectiles fired with long ranges under great angles of elevation, upon scarps covered by earthen masks placed some distance in advance of the scarps, cannot fail to be productive of much damage wherever the projectile attains the scarp, although from the uncertainty of the fire on a hidden

Exceptional cases of this character demand a special study on the part of the engineer to devise the best mode of meeting their requirements.

Fig.22.

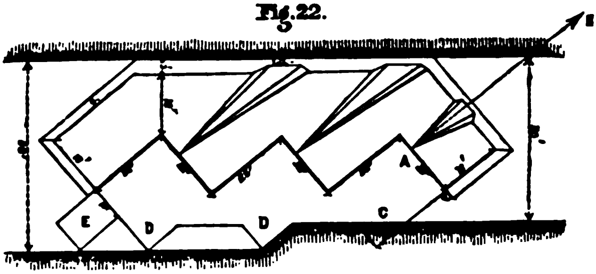

Fig. 22. (See Par. 89, page 204.) Plan of an Indented or Cremaillière Sunken Battery on a Causeway from 50 to 60 feet wide. A B, Line of direction of fire; C, Contraction of rear of battery; D D, Enlargement of rear of battery; E, Ramp.

the direction of their fire may be as nearly perpendicular as practicable to the line of wall to be breached; and where these lines are oblique to each other, the obliquity should not exceed 45°, otherwise the effect of the shot will be greatly diminished and the operation retarded.

75. Besides the breach batteries, it may be necessary to place counter-batteries on the glacis. Their object will be to counter-batter and silence the artillery of those portions of the defences which can be brought to bear on the breach batteries, or on the passages of the ditches. These counter-batteries will usually be so placed as to fire along the ditches of the defences. Their arrangement, in all respects, will be the same as that of the breach batteries.

76. When the site of a battery is marshy, the construction of the parapet and the laying of the platforms require great care to give them the requisite strength and firmness. Each of these parts should receive a firm bottoming of two layers of long fascines, 12 inches in diameter, the border for a breadth of 2 or 3 feet receiving a thickness of 3 or 4 layers, the first well covered with sand or rammed clay, if they can be obtained, before placing the second layer, which should cross the first at right angles, and be well picketed to it. On this bed the parapet is raised, and, if the adjacent soil of which it is formed is very wet, layers of smaller fascines may be advantageously used at different heights to prevent the wet soil from running. The site of the guns should be covered, to a depth of at least 6 inches, with moist sand, or good loam well rammed, to receive the platforms; which, like those at the sieges of Forts Pulaski and Wagner, should rest on a bed of plank, over which the weight of the guns should be well distributed by the under timbers of the platform.

77. On a site of solid rock the only means that can be well employed for constructing the parapet is sand-bags. If the surface of the rock on which the platforms are to rest, is too uneven or too much inclined to be easily levelled by hammers, it will be necessary to fill in the space required for the service of the guns with earth or sand, and to use a cribwork if necessary around the border of the interior to confine the soil, which, as in the case of a marshy soil, should be well rammed and levelled before laying the platforms.

Exceptional cases of this character demand a special study on the part of the engineer to devise the best mode of meeting their requirements.

Fig. 22.

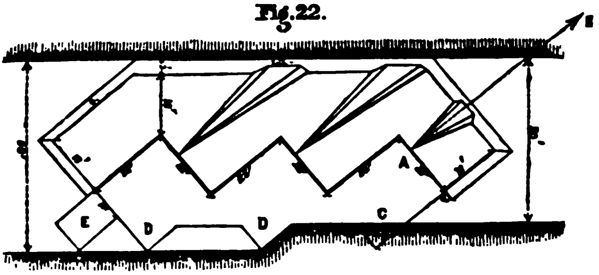

Fig. 22. (See Par. 89, page 204.) Plan of an Indented or Cremaillière Sunken Battery on a Causeway from 50 to 60 feet wide. A B, Line of direction of fire; C, Contraction of rear of battery; D D, Enlargement of rear of battery; E, Ramp.

CHAPTER IV.

SIEGE OPERATIONS—ATTACK.

78. UNDER this head are included all the operations which are usually necessary for attacking and reducing a fortified position by the method of regular approaches.

These operations are classified under three distinct and general heads, termed *periods* of the siege.

79. The *First Period* comprises all the movements of troops and other necessary measures which are taken to cut off communication with the position from without, termed the *Investment*, and to establish the besieging force in a secure position from the attacks of the garrison of the besieged place, and from any force that might attempt to give it succor.

The *Second Period* comprises all the operations from the first breaking of ground for approaching the place, termed the *Opening of the Trenches*, to the completion of the third parallel, or gaining a position from which an open assault, if deemed advisable, may be attempted against the most advanced and weakest of the besieged works.

The *Third Period* comprises all the subsequent operations to the surrender of the place.

These divisions, although of an arbitrary character, it will be seen from the nature of the operations, present three quite distinct phases of sieges generally.

FIRST PERIOD.

80. As a siege is an operation of considerable duration, it supposes that every preparation, both in troops and *matériel*, has been carefully made, and all the necessary measures for carrying it into effect have been well matured before the besieging force is put in motion.

These measures consist—1. In ascertaining, as far as practica ble from every source of information, the strength of the work to be besieged; that of its garrison, and its means for supporting a siege, as to provisions, munitions of war, etc. 2. In investing the place by a sufficient force to cut off its communications from without. 3. The marching and posting of the entire besieging force in position around the besieged work. 4. In securing the positions taken up by suitable intrenchments against assaults either by the garrison or a succoring force. 5. In making every necessary preparation for opening the trenches against the place. 6. And finally, in deciding upon the points of the besieged work against which the approaches are to be made, and which is termed the *Point of Attack.*

81. **Investment.** The main objects of this operation are to cut off all communication between the garrison and the exterior; to prevent succors of every kind from being thrown into the work; to sweep off everything in its vicinity that might, in any way, be serviceable to the garrison; and, finally, to cover a close reconnaissance of the defences by engineer and other officers.

82. For the successful attainment of these ends, the investing force, which should be mainly if not solely composed of cavalry, moves upon the work with celerity and secresy; and, after surrounding and securing all avenues to it, sends out detachments to scour the environs up to the very gates of the work, if practicable, and bring off with them, or destroy all persons, cattle, provisions, etc., met with. A chain of posts and sentinels is in the mean time established in the best positions to prevent all access to the work, or egress from it; care being taken to select for the posts points which are not exposed to the artillery of the work, or are beyond its range. The posts occupied by the troops during the day-time, and termed the *Daily Cordon*, are shifted at dark, and points nearer the work are taken up, to form the *Nightly Cordon* and hem the work in more closely. The posts and sentinels for this purpose should be pushed as far forward as they can find shelters from the musketry of the defences; and under their protection the reconnoitring officers should spare no efforts to gain an exact idea of all the ground exterior to the work, and of the character of the defences.

83. **Posting Besieging Force.** The main body of the besieging army, with the engineer and artillery siege trains, follows closely upon the investing corps, to prevent the line taken up by

the latter, which, from its extent, is necessarily weak, from being forced either by the garrison, or by strong detachments from without. The positions for the camps of the various corps are designated by the commanding general, after a careful reconnaissance. These are placed beyond the range of the heavy artillery of the works, with their color fronts facing from the works; and, as far as practicable, on points favorable to the health and comfort of the troops, and the defence. Whenever natural obstacles, as marshes, rivers, etc., occur between the camps they must be crossed by good lines of communication, so that no impediment may be offered to the speedy concentration of the troops upon any point threatened from without.

Besides the positions taken up for the camps, the besieging force will also occupy all points exterior to the camps, within cannon range, by which they are commanded, securing them by field works of sufficient strength to subserve the end in view.

84. Intrenchments of Camps. The front and the rear of camps are also secured by lines of field works. The exterior line of works, termed the *Line of Circumvallation*, should form an unbroken line of intrenchments composed of the most simple elementary parts, as tenailles, redans, etc., with a slight profile; its chief object being to prevent succors of small detachments from slipping into the place. The interior line, termed the *Line of Countervallation*, is composed of detached works, which, if the garrison is strong, should be in defensive relations. The main points which should be occupied by these works are the principal avenues to the defences, and the positions selected for the parks of the siege train; to secure these points from the attempts of the garrison, and to render the entrance of large convoys into the defences impracticable.

The lines are so placed as to leave a space of about 200 yards between them and the front and rear of the camps.

85. When the great extent of ground that must be taken up by a besieging force, in the investment of any considerable position, which requires to be entirely surrounded to cut off all communication between it and the exterior, is taken into consideration, particularly now when rifled guns have acquired such long ranges, it will be seen that complete lines of circumvallation will be seldom practicable, and in most cases must be of too weak a

character to serve as an intrenched defensive position for the besieging force to receive battle within them.

Accordingly, in the later sieges in Europe, continuous lines of circumvallation have been seldom resorted to; the besiegers contenting themselves with occupying only the main points of their position by field works, and giving the intervening space such protection as could be afforded by strong patroles and posts. This departure from former practice arose, in most cases, from the want of strength of the besieging force, and was frequently attended by the very events against which lines are chiefly effectual in guarding. As a field of battle against a succoring force of sufficient strength to cope with the besieging army, a position taken behind a line of circumvallation is but in rare exceptions eligible, a maxim that applies to all extended and weak lines; and in almost every case, where a serious effort has been made against such positions, it has proved successful, and has entailed heavy loss on the besiegers. But, it must be repeated, as this is not the object of these lines, they are not open to this objection; and, as they have been found serviceable for the sole purpose to which they should be applied, they ought to be thrown up in all cases where the means of the besiegers will admit of it.

86. **Army of Observation.** No important siege, however, should be undertaken where there is danger from a heavy succoring force from without, unless the besieging force is of sufficient strength not only to keep the garrison within their works whilst the ordinary siege operations are pushed forward, but to detach a force of sufficient strength to observe the movements of any body that may seem large enough to threaten the besieging force and to hold it in check long enough, if attacked, to concentrate the entire force on some favorable defensive position.

87. **Preparations for Opening the Trenches.** Whilst the besieging force is occupied in arranging and securing their camps, a portion of it is employed in preparing the trench materials, establishing the parks, and getting everything in order preparatory to breaking ground against the defences. At the same time close reconnaissances and careful instrumental surveys are made by the staff corps, to obtain *data* for a map of the defences and their environs, with a view of drawing up a plan of attack. With this object the bearing and prolongations of the faces and

capitals of all the defences should be carefully laid down; the character of the defences on every assailable point noted; that of the parts bearing on these points, and the nature of the ground over which they must be approached.

88. The parks, magazines of powder, and other *depôts*, should be placed on the most secure points, beyond the range of the heavy artillery of the defences, and, if practicable, should be hidden from their view. The points selected, if not in the immediate neighborhood of the ground on which it is decided to open the trenches, should have avenues of easy access to it, for the transportation of whatever may be requisite in carrying forward the works of attack.

89. **Point of Attack.** After obtaining all the information that can be had from reconnaissances, surveys, and other sources, the next object is to decide upon the portion of the defences which it will be necessary to gain possession of to force the garrison to a surrender; this portion, which usually embraces one or more fronts of the position, with the outworks and any advanced works that may be connected with them, and which must be reduced before the points of the main work can be assailed, is termed the *Point of Attack.*

90. It is in the choice of this point—a decision which mainly rests with the commanding officer of the engineers—that the judgment and skill of this officer are shown. In making this selection, not only must the relative strength of the various points of the defences which are accessible be carefully weighed, but the nature of the site as to soil, natural surface, etc., upon which the trenches and other works of the attack must be laid out, and the facilities afforded of an easy communication between the parks, *depôts*, etc., and the point selected.

91. In considering the strength of the defences, those parts are regarded as unassailable by the ordinary measures of an attack, which border upon precipices, marshes, a water-course that cannot be forded; or are protected by works on inaccessible points, the fire from which sweeps in flank and reverse the ground over which the trenches must be run. Those parts, again, are considered as offering peculiar difficulties which present a series of works in good defensive relations which can only be carried in succession; or works which are mined; or those which have their ditches arranged for a play of water; which

have dry ditches of unusual depth; or, those parts where the works to be carried are displayed on a right line, embracing nearly the same extent of front that the besiegers can take up with their trenches; or, finally, portions which present a concave front to the attack.

92. The points which are looked upon as most advantageous to the attack are those in which the general combination of the works forms a salient point with respect to the rest of the defences; as a point so situated can receive but little support from the collateral portions, and can be enveloped by a line of trench of much greater extent than itself, along which positions can be obtained for enfilading and other batteries, the fire of which will be convergent upon that of the defences.

93. As regards the site on which the trenches and other works must be laid out, the difficulties presented to their construction by bare rock, marsh, or hard stony ground, may be readily appreciated; as cover can only be had on the two first by bringing the earth from a distance to form the parapets, dikes, etc., and on the last not only from the great labor requisite in digging the trenches, but from the annoyance and injury to the troops from the fragments of stone scattered in all directions by the shot of the defences.

94. But, besides these features, there are others, less obvious which should be taken advantage of or be avoided, as favorabl or otherwise to the construction of the works of the attack. A surface, for example, which slopes or falls away towards the defences, if commanded by them, is unfavorable both to the construction of trenches and batteries; as, to gain sufficient cover, both the parapet and trench will have to receive dimensions greater than under ordinary circumstances; and the defilement of approaches run upon it will also be less easily effected. A surface which rises towards the defences is very favorable both for gaining cover speedily, and for defiling with advantage the approaches; but is less so as a site for batteries if the slope is at all steep. An undulating surface may offer, in some points, natural covers, and be at other points favorable as sites for batteries; this will depend upon the position of the undulation of the surface with respect to the fire of the defences. A ridge, for example, leading out from the defences, whilst it would present a cover to the works on one side of it from the fire of the defences, on the other, would expose the trenches on the other side of it to a plunging fire from the same points. A narrow valley similarly placed would be very unfavorable, as both of its sides would be exposed to a plunging fire.

Rolling ground, where the valleys and ridges are sensibly parallel to the point of attack, if the ridges cover well the valleys to their rear from the fire of the besieged works, will offer excellent shelter and great facilities for pushing forward the works.

SECOND PERIOD.

95. Plan of Attack. The plan of the attack, or the positions which, upon a careful examination of all the information at the disposal of the officer commanding the besieging force, it is decided to give to the parallels and the approaches, and the means to be employed, at the successive stages of this period, for throwing up and guarding all the works of the attack, will necessarily depend upon the natural features of the site over which the trenches are to be run, and the defences of the besieged which, in any manner, have a bearing upon the trenches.

96. Vauban, whose great experience and success in conducting sieges has made him an authority on this subject, has laid down certain precepts upon it, of which sieges conducted subsequent to his time have confirmed the value. The following are those which chiefly bear on the Second Period of the attack:

1. To delay the opening of the trenches until the besieging forces are all well posted, and made secure by fortifications from an attack either from the garrison or from a succoring force; and until every thing requisite for carrying on the work vigorously has been collected and is ready at hand when wanted.

2. To make a single attack rather than a double one unless the two attacks can be well connected and the besieging force exceeds considerably in strength the garrison. This, as a matter of course, excludes false attacks, and double separate attacks, unless the superiority of the besieging force is very great.

By a single attack is understood one by which it is proposed to gain possession of the main work by a single breach at some point; by a double attack it is proposed to effect two breaches of the main work. The advantage of the latter lies in forcing the garrison to divide their strength for the defence of the two breaches, whilst the assailing forces, being under one leadership, can at any moment concentrate if necessary upon the point most favorable to their assault.

3. To embrace within the parallels and approaches all the defences which bear upon the site to be occupied by the besieger's works, in order to have secure positions for establishing the batteries that may be required to silence the fire of these defences.

4. To multiply the approaches, with the view of giving mutual support, less encumbered communications, and dividing the fire of the defences, which, if concentrated upon a single one, might soon destroy it.

5. To throw up at least three main lines or parallels, placing them in the best positions for mutual support and for guarding the approaches and batteries from sorties of the besieged.

6. To avoid attacking a point upon which the approaches can be run only on a narrow front; or one which can only be approached over marshy ground, or on causeways.

7. To be careful not to push forward any portion of the trenches until they are well flanked and protected by trenches in their rear which are completed and occupied by troops.

8. To avoid encumbering the approaches with trench materials, tools, workmen, or troops; placing all of these in the parallels, on the right and left of the approaches, so as to be ready at hand when wanted, and to be rapidly sent forward through the trenches of the approaches which should be kept free for this purpose.

9. To place the ricochet batteries in such positions that they can have an enfilading and slant reverse fire upon the guns of the defences to be attained by them.

10. To refrain from opening fire from any series of batteries until it can be done at the same moment from all of them.

In connexion with this and other siege operations, Vauban remarks, that precipitation in sieges does not hasten the close of them, but often prolongs them and renders them more bloody.

11. To employ the fire of the batteries and trenches, rather than open assaults, to drive the besieged from their defences, before attempting to occupy them by the besieging force.

12. When it is decided to make an open assault, to do so by day, if there is no portion of the fire of the defences, which bears upon the point to be carried, that is not completely kept under by the fire of the batteries and trenches; but, in the contrary case, when the fire of the defences is not completely kept under, to make a night assault.

13. Not to attempt an obstinate resistance to an open assault of the besieged upon any unfinished portion of the trenches; but rather to withdraw the workmen and the few troops near them, to some point behind the parallel immediately in the rear, and then to open a vigorous fire from it upon the assailing force.

14. To keep within the cover of the parallels when the assailant is advancing to the assault, and leave him to expose himself to its fire as long as he pleases, and then, when he is well cut up, and has got thrown into confusion, as he necessarily will at night, in the trenches that he may have carried, to fall upon him with the bayonet and drive him out.

15. Not to push such charges too far from the parallel, but to retire promptly, so soon as the assailant has fairly taken to flight, within the cover of the parallel, so as not to draw the fire of the besieged works.

These general maxims of Vauban are the teachings of a wide experience, and of a mind peculiarly endowed with a just perception of the demands of this branch of the military art. It may safely be averred, wherever they have been carefully attended to and an adequate besieging force has been provided, that success, at the least expenditure of time and blood, has been the result; whereas, many and striking examples show the contrary to have obtained where they have been unheeded.

97. **Parallels.** Vauban, in his maxims, prescribes that there shall be at least three parallels, or places-of-arms to be occupied by the troops of the besieging force immediately on duty, with a view to meet any sorties of the garrison on the besieger's works; and further, that these parallels should embrace so wide a front as to control all the defences which bear in any manner upon the ground over which the besiegers will have to run their trenches.

98. **1st Parallel.** In Vauban's time, and to within quite a recent day, it was considered that when the site was completely

exposed to the fire of the besieged, the 1st parallel (Fig. 32) might be laid out at about 600 yards from the most advanced points of the defences to be embraced within it, and concentric with a line joining these points, and extended so far each way as to guard all the batteries thrown up along its front to silence the fire of the defences, from assaults in front and on either flank of the parallel. This position of the 1st parallel, Vauban makes dependent on the site, as affording more or less of shelter from the fire of the defences; and, at the celebrated siege of Sebastopol, the French established their 1st parallels at two separate points, the one at nearly 1000 yards, the other at nearly 1800 yards from the defences; and the English, in their attack, also placed their 1st parallel at nearly 1800 yards from the defences in their front. This departure from usage was owing to the great calibre of the guns and the large quantity of fire of the Russian defences. Instead of three parallels, the French found it necessary to throw up seven, the nearest of which to the Russian defences was about 30 yards, when the final open assault was made from it upon the key point of the Russian position.

99. The greater range and accuracy of fire of rifled guns will necessarily lead to establishing the first batteries against the defences at much greater distances than formerly, when smooth bores were alone used; and assuming the 30-pounder, as the probable largest ordinary calibre of siege guns for the attack, the first batteries will probably, in future sieges, occupy positions at from 2,000 to 3,000 yards from the defences. These distances will secure for these batteries, what is essential for all those of the attack, a good range for destroying the artillery of the defences, and security, if properly guarded, either by placing them within strong enclosed works, with sufficient troops to defend the works, or by troops occupying trenches so disposed as to meet a front or flank attack on the battery. Anything like a continuous line of parallel would seldom be requisite at this distance, as the garrison would hardly venture sorties so far from their defences. Besides which, considering the great extent of front that the batteries would have to embrace at this distance, to control all the fire of the defences, it would require too great a length of continuous entrenchment.

100. **2d Parallel.** Tactical considerations require that, in the establishment of the successive parallels, the one most

advanced should be laid out nearer to the one in its rear, by which the workmen completing the former are protected, than to the defences; so that it can receive timely succor against an assault upon it by the besieged.

Considering the first line of batteries and trenches as a 1st parallel, the position of the 2d parallel may be safely placed at 1,000 yards in advance of it; that is, nearer to it by 100 yards or more than to the defences.

101. 3d Parallel. As it is usual to place the 3d parallel (Fig. 33) so near to the defences as to bring the covered ways, or other most advanced defences, which may be assaulted openly, within range of stone mortars, placed in batteries either within or in front of this parallel; its position, for this object, should be some 60 yards from the salient points of the most advanced portions of the defences, so as to bring their interior within the range of the stones and other missiles thrown from the mortars.

102. Demi-Parallels. In giving the 3d parallel this position, there will be a wide zone of ground between it and the 2d parallel, over which the approaches connecting these two parallels must be run, which would be very much exposed to the sorties of the besieged, as well as the 3d parallel, were its protection left to troops stationed as a guard in the 2d parallel. To provide protection for these approaches and for the 3d parallel, whilst in process of construction, ends of trenches, termed *demi-parallels*, are run out, on the right and left of the lines of the approaches, far enough to contain sufficient bodies of troops to protect the men working on the trenches in advance of them from sorties.

The positions of the demi-parallels will be regulated by the same tactical considerations as those which regulate the positions of the parallels. The length to which they should be extended on the flanks of the approach, will be regulated by the number of troops that it may be deemed necessary to post within them, and also from the consideration that they shall not obstruct or be endangered by the fire of any batteries to their rear.

103. Approaches. The successors of Vauban followed up, as far as practicable, the methodical stages in conducting the attack founded upon his long experience; and which consisted in a single, or a double connected attack; approaching the points assailed by as many lines of communication, directed upon them, as circumstances seemed to demand, and protecting these approaches by three continuous main lines of trenches, termed the parallels, and several portions of parallels, termed demi-parallels, placed between the second and third parallels, all of them so placed as to be in good tactical relations to each other.

104. The approaches were usually run in zigzag directions towards the salients of the defences, crossing the lines of the capitals of these salients; the front of each approach gradually contracting as it was advanced towards the salient; and each boyau of the approach receiving such a direction as not to expose it to an enfilading fire from any point of the defences within cannon range.

105. In addition to the communications between the parallels, two or more lines of approaches were run, from the positions selected for the depôts of the trenches, to points of the 1st parallel convenient for the supplies for this and the other lines of works. These were also usually run in the direction of the capitals of some two or more of the salients.

106. Besides giving the boyaux directions unfavorable to an enfilading fire from the defences, each one was extended some 10 or 12 yards back, to the rear of the one behind it, so that should the besieged endeavor to take up a temporary position, exterior to his main defences, each boyau would still be covered by the portion of the one in advance of it run to the rear, not only from an enfilading, but from any slant reverse views, except from points so far beyond the defences as to make their temporary occupation very perilous to the besieged, from their exposure to open assaults.

107. The positions given to the approaches along the capitals are not obligatory; but will generally be found to offer more advantages than any other that could be given them on ground entirely unobstructed. In the first place, the capitals are the shortest lines from the parallels to the salients of the defences. In the second, by running the boyaux across the capitals, and gradually diminishing the extent of their front, the entire approach will be better flanked by the fire of the parallel in its rear; will be in a position to receive but little if any of the fire which is delivered from the two faces of the salient upon which it is run; will be out of the line of fire of the batteries enfilading these two faces; and will usually be in the most favorable position to defile each boyau from the fire of the besieged.

108. The front occupied by each approach will depend upon the length given to each boyau. As a general rule, the boyaux should not receive a greater length than 100 yards, in order not to expose too long a line to tempt the besieged to enfilade it; and the approach may be started at the 1st parallel with a front of 60 yards, which should be gradually narrowed, so as to have a front of about 30 yards at the position of the 3d parallel.

109. Batteries. The batteries used for this period of the siege consist of two classes, *fixed* and *movable*. The fixed batteries will contain the siege guns and mortars of the heaviest calibre and longest range; whilst the movable batteries will consist of field guns and small mortars which can take up temporarily any favorable positions for damaging the defences.

110. As a general rule the fixed gun batteries should be placed in enfilading positions whenever such can be found for them, delivering their fire always within the interior slope of the face enfiladed, and in preference taking a slant reverse direction on the terre-plein of the face. Parts of the defences which cannot be reached by enfilade must be counter-battered by batteries which can obtain a full front or a slant front view upon them.

111. The mortar batteries will receive such positions as are most favorable for reaching the interior of the defences; preference being given to those in which the longest lines of the defences can be brought within the range and direction of the shells; avoiding, whenever practicable, throwing them across the positions occupied by the approaches, so as to insure a shell being landed within some point of the defences, and to avoid the accidents from shells falling short of their butt or bursting prematurely.

112. The positions of the fixed batteries of rifled guns and heavy mortars, will be usually along the position of the 1st parallel and some 30 or 40 yards in advance of it, so that its service shall not interfere with that of the parallel, nor the service of the latter with it, a point of great importance for the efficient service of each; and being in advance of the parallel the troops in the latter will not be annoyed by the discharge of the guns which they might be were they in their rear.

113. As the ricochet of rifled guns with the elongated shot is uncertain, and from the great range at which the guns fire, the plunge of the projectile would be necessarily great and unfavorable to ricochet, positions for fixed enfilading batteries of smooth-bore siege guns may be taken either in advance of the 2d parallel or better in some of the demi-parallels, so as to bring them within some 500 yards of the line to be enfiladed, as a range very favorable for the ricochet of these pieces.

114. The movable gun batteries will consist of 10, in some cases, 20-pounder rifled guns; and the Napoleon gun for throwing hollow projectiles. These guns will take advantage of any temporary covers, as undulations of the ground, woods, fences, etc., from which they can bring a damaging fire on the defences, and which they will maintain until the fire of the besieged becomes too heavy for them. In this way, a very important auxiliary to the fixed batteries will be called into play; sometimes forcing the besieged to establish new positions to drive off these light guns.

In like manner the smaller mortars that can be readily moved by hand, or on sleds, may be placed in good temporary positions to increase the amount of fire delivered on any given point.

115. Strength of Batteries. The number of guns in each enfilading battery will depend upon the extent of terre-plein within the works upon which an enfilade, or a slant, reverse fire can be obtained. Usually, the number of guns should not exceed seven, nor be less than three; the number being regulated by the importance to the besieged of the line enfiladed.

116. In each counter-battery there should be at least as many guns as the defences can bring to bear upon it; always enough to completely control the fire of the point counter-battered. Whilst batteries containing a large number of guns are exposed to greater casualties than smaller ones, weak batteries are liable to be silenced by a concentrated fire upon them from the defences.

117. As a general rule, batteries at different distances should be so placed that the more advanced should not be in the line of fire of those in rear. The danger from accidents from a violation of this rule is not very great if the batteries are several hundred yards apart, and the point fired at distant; or until the trenches get near the position of the 3d parallel. At this stage, great precaution is necessary in regulating the fire so that the shot may not fall into or explode too near the trenches.

As an illustration of this, let the two faces of the redan, A B C (Fig. 34), be each 100 yards long; and, on the prolongation of

A B, assume the two distances, A D and A E, respectively, at 1,000 and 2,000 yards. Now supposing the width of the terre-plein along A B to be 10 yards, a gun placed at G, at 200 yards from E, firing at the point, A, would just take the diagonal of the terre-plein, and its shot would pass at F, 100 yards from D; so that a battery of six guns, occupying about 40 yards front, could enfilade the terre-plein of A B, and still leave 60 yards for the fire of the battery placed from G, towards E, to pass to its left.

Fig. 34.

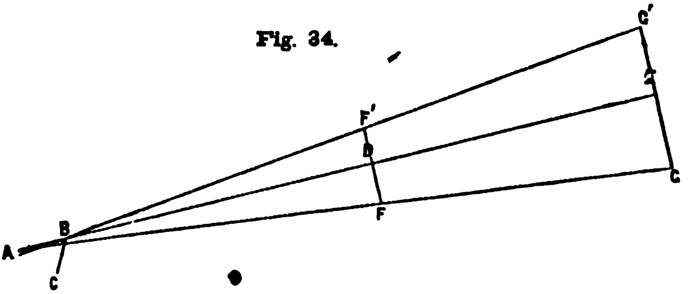

Fig. 34. A B, Face enfiladed; G G', Front of enfilading batteries on 1st Parallel; F F', Front of enfilading batteries on 2d Parallel.

Taking, in like manner, the other diagonal of the terre-plein, through the salient, B, and prolonging it to F' and G', to intersect the two parallels, the distances, E G' and D F', will be found respectively 190 and 90 yards; so that on the 1st parallel there will be 190 yards along which every gun will have a very slant front fire on the parapet of A B, and every shot can be brought to sweep the entire length of the terre-plein; whilst on the 2d parallel there will be a length of 90 yards adapted to the same purpose.

From four to six mortars are usually placed in each mortar battery, and these batteries are distributed along the front of attack in the best positions for accomplishing their objects.

118. Blinded Batteries. In view of the great improvement in range, and the accuracy of fire of rifled guns, and of the greatly increased amount of both guns and mortars shown in the more recent sieges, the question of armored parapets and of bomb-proof blinds for the protection of the guns of the batteries in the position of the 2d parallel, is one demanding consideration. When the batteries are not exposed to flank or very oblique slant views, chambers or casemates of timber, with strong bomb-proof roofs and sides with sufficient cover and strength to resist any chance shots, might be easily constructed, restricting the dimensions of each casemate to what will be strictly requisite for the manœuvres of the gun in it.

The entire front of the battery might be guarded from direct shot, particularly of elongated projectiles, by laying heavy logs or iron rails in an inclined position against the exterior slope and covering them with sand-bags, leaving only enough embrasure opening in front, both horizontally and vertically, for the field of fire wanted. Considering the range of these batteries at this distance of the 2d parallel they might be sunk, so as to place them in greater security and effect their construction more readily.

119. Sorties. The policy of the besiegers is to expose as little as possible to the chances of hand to hand conflicts, but to endeavor to gain their ends by the action of their artillery, and by skill and perseverance pushing forward their trenches until they can reach the last position that the besieged can take up, still keeping under cover. The besieged, however, are often constrained to a bolder course; sometimes to open the way for succors to reach them; and sometimes to avail themselves of opportunities presented by the mistakes of the besiegers to drive them from their trenches, spike the guns of their batteries, and even destroy their depôts.

The parallels and their guards are to provide against such attacks; and, with proper measures and due vigilance, they ought never to succeed, but the besieged be made to pay dearly for each attempt. In past sieges, when the 1st parallel was usually opened at about 600 yards from the defences, a sortie against it was regarded as a very uncertain operation, and only to be attempted when the garrison was strong and had a respectable force of cavalry and of light batteries to act with their infantry in the sortie. This contingency, however, should be guarded against by having the flanks of the 1st parallel secured by a redoubt armed with field guns; with epaulments for cavalry thrown up a few hundred yards to the rear of the flanks; and by a suitable reserve ready to move forward at a moment's notice to the support of the troops in the parallel.

120. After the 1st parallel is completed and occupied by the guards, the besieged will seldom attempt a sortie in force before the ground is broken upon the position of the 2d parallel, and the besiegers should be prepared for this probability by having an extra force in and near the 1st parallel, to support the few guards who may be in the advanced boyaux for the protection of the workmen from the sorties of small bodies. So soon as a serious movement of the besieged beyond their defences is observed, the working parties should be withdrawn in a prompt and orderly manner, taking with them their trenching tools, along the approaches, the guards in these covering their movement to rear, thus leaving the front of the 1st parallel unmasked to deliver its fire on the sortie. No effort is made to check the sortie except by the fire of the trenches until the troops composing it have reached the advanced trenches, when a charge may be made over the steps made for that purpose in the trench and parapet of the parallel, or through breaks left in the parallel itself of sufficient width for the passage of a column of infantry.

From the completion and occupation of the 2d parallel, none but sorties of small bodies, seldom exceeding fifteen men, are to be apprehended, with the object of temporarily stopping some approach.

121. Opening the Trenches. This operation supposes that all the measures preparatory to it have been taken; the *depôts* of trench materials established and well provided; careful reconnaissances of the site and the defences made; an accurate map made, from such instrumental surveys as were practicable, and other information gained; the positions of the defences marked out upon the map giving the directions of the faces and capitals of the principal works; the distances and heights of their salient points from that of the 1st parallel, etc.; and the approximate positions of the 1st parallel and of the approaches to it from the depôts in its rear, and of those leading from it upon the defences.

122. With the *data* furnished from these sources, the engineers can proceed to stake out upon the ground the directions of the portions of the trenches upon which ground is to be first broken, either on the same night, or a night or two before, as opportunity may serve. This duty is readily performed with the aid of rough sketches, dark lanterns, small pocket compasses, and pickets painted white, with all of which the officers are provided, and with the aid of several intelligent non-commissioned officers or soldiers of the engineer troops.

123. Everything being in readiness, the workmen are assembled in detachments, at the proper moment towards night-fall, at the depôts of the trenches, where they receive their trenching tools, and whatever else is necessary to carry on the work with. They are then led, in single file, to the positions they are to occupy in breaking ground, by an officer or engineer soldier; sometimes each man grasping with the right or left hand a tracing rope or tape, on which his position is marked in the usual way, or else the tracing-tape is first stretched and the men placed in their position near it.

124. When once in position, the working parties are commanded to lie down and keep perfectly quiet until ordered to rise and commence work; to give time to the engineer officers to rectify any mistakes of direction in the lines. So soon as this is done, the order is given to rise and break ground. This will be done by each man digging a hole as speedily as possible, and throwing the earth towards the defences, so as to give cover for himself, and from which he can gradually, and with security, work forward in the direction of the trench he is to excavate. This operation is supervised by the engineers on duty, who see that any mistakes made by the men digging are corrected at the proper moment.

125. In the prosecution of the works during this period, the simple trench, flying sap, or full sap will be used, as opportunity may offer, and as the fire of the defences is more or less certain and destructive. As the flying sap will afford the most speedy cover against case shot, it will be employed generally so soon as the trenches have been advanced within destructive range of this; using, however, the simple trench at night, or at any other opportune moment. The full sap must be used when within the certain range of small-arms, and when the cannon fire of the defences is very deadly; resorting, however, to the flying sap whenever the risk is but slight.

126. Journal of the Attack. In actual siege operations a daily record is made by each engineer officer on duty in the trenches, of the amount of work done, the time required, the means of execution, etc., with any observations that may seem of value. These records are transmitted to the head-quarters of the commanding engineer, where they are filed away for reference, and from them the progress of the trenches is carefully laid down upon the original directing plan of the attack.

127. From the data furnished by such records, and from the results obtained in the schools for training engineer troops, the average time required for executing the various portions of the siege works, under ordinary circumstances, during the different epochs into which they have been divided, has been laid down by writers on this subject. This mode of calculation has also been applied to test the relative value of different systems of permanent fortifications, by submitting them to a fictitious siege, and estimating from the time, as shown in this way, required for their reduction, how much longer the one system would hold out than the other.

However ingenious this method may at first appear, it affords no real practical test of any importance; the duration of sieges depending upon moral and physical laws, as their whole history has shown, that no mode of calculation can reach.

The immediate successors of Vauban, who made use of these calculations in theoretical sieges, have usually allowed nine days, from the opening of the trenches to the completion of the 3d parallel; estimating that all the batteries, along the front of the 1st and 2d parallels, would be completed on the sixth day, and the fire of the defences be brought under in twenty-four hours after the batteries were in full play.

THIRD PERIOD.

128. The works of this period consist of the batteries and other establishments necessary to drive the besieged from their covered-ways, or other defences exterior to the ditches, such as rifle pits, or rifle trenches, to enable the besiegers to push forward, without too great risk and loss, their approaches to positions along the ditches of these works, where they can establish breaching and counter-batteries against them; and of the measures to be taken to gain possession of the breaches, when rendered practicable, either by an open assault in force, or by gradual approaches gaining and securing each foot of ground by the sap.

129. The 3d parallel (Fig. 33), having been extended only so far as to embrace the immediate point of attack, and to secure the guards from a flank attack, from the works adjacent to this point; and having been widened, 3 or 4 feet, beyond the width given to the other parallels, to give more room, both for the guards and for a temporary depôt for the trench materials for the works in the advance; sunken batteries, for stone and small mortars, are constructed, either in this parallel or some 20 yards in advance of it, in the best positions for driving the besieged from their exterior defences by the fire of these mortars, and at the same time not to injure or annoy the men who are pushing forward approaches from the parallel upon the salient points of these exterior defences.

130. At this stage, when these batteries are about ready to open fire, a decision must be come to whether to attempt to carry the covered-way and any defences exterior to it, by an open assault, from the position of the 3d parallel; or to advance upon them by regular approaches. This decision must depend upon many contingencies; as the strength of the garrison and the conduct they have shown throughout the siege; the more or less difficulty presented by the works themselves to an open assault, either from their intrinsic strength, or from the support given them by the works which cannot be assailed in the same way; the probability of a strong succoring force coming up before the works can be gained by regular approaches; the more or less probability of success, and the cost of life with which even success must be attended.

131. The history of sieges and the best engineering authorities are decidedly unfavorable to open assaults, except at the last moment, and when the assailed can oppose no other obstacle to the besiegers than a body of troops in front, with no defences between them and the assailing force. Vauban always opposed open assaults, where there was any means of a vigorous resistance by the besieged. On one or two occasions, when overruled in his opinion, the soundness of his views was fully borne out by the event. The history of the more recent sieges abroad, and late examples of our own siege operations, show how uncertain are the successes from open assaults, and, even when successful, that they entail great loss of life and injury upon the assailant.

132. When an open assault, however, is decided to be made on the covered-way, or any other works exterior to the ditches, no pains should be omitted to secure its success. The troops chosen for the assault should be picked, tried men, and be in sufficient force to break through all probable direct opposition from the besieged; and should be supported by a reserve, to guard them from a sortie on their flanks or rear, and to cover their retreat if forced back. The 3d parallel should be prepared with steps, on the points from which the troops are to sally out of the parallel, to an extent equal to the front of the assaulting column. The hour fixed upon for the assault will depend upon the strength of the besieged and upon the habits of their troops. Night assaults have the advantage of less exposure to the fire of the defence; but they are uncertain in their results, from the confusion with which they are almost necessarily attended. They are best made at the close of the day, when the obscurity is so great as to render it difficult to discern objects at some distance, but still affording light enough for men to see well just around them.

133. Whenever made, the way is prepared for the assailing force by a heavy and long continued fire upon the point to be carried and all the defences bearing upon it, from every position of the trenches, from which fire can be opened on these points. When this storm of missiles has apparently done its work, by silencing the fire of the defences and driving the besieged out of the work to be assaulted, the assailing columns rush rapidly upon the points to be carried, and driving any troops of the besieged from them who may still be holding on, retain possession of the points gained and repel any attempt to recover them, until the party of engineer troops and workmen, who should follow directly in their rear, have thrown up defences which will give the assailing force temporary cover against the further attempts of the besieged.

134. If, however, it is decided to work forward by gradual approaches, the besiegers, to gain room for a depôt of trenches near at hand, commence a trench, leading from the 3d parallel, by the full sap, at starting points some 60 yards on each side of the capitals of the salients on which they have decided to advance, giving the two branches of this trench a direction such that they will unite on the capital and some 15 yards in advance of the

3d parallel. These two branches may each be in a right line, but they are not unfrequently worked round on an arc, and hence this portion of trench has received the name of the circular place-of-arms.

135. In the meanwhile, other approaches may be pushed forward from the 3d parallel directly on retired points between the salients, which it may be desirable to reach as soon after the salient points have been reached as practicable. As the direction taken to reach these retired points will be towards a reëntering, the double direct sap will have to be used; and as an approach of this kind can only serve as a communication, short ends of trenches should be run out by the full sap on the right or left of each such line of approach, so as to flank it and contain a small number of guards to protect the sappers from small sorties.

136. From the circular place-of-arms a direct approach by double sap is pushed forward along the capitals to within about 30 yards of the salients, a position where trench cavaliers can be erected from which grenades may be thrown into the salients, and sharp-shooters can be placed to expel the besieged from any covers he may have found shelter behind. The practicability of throwing up trench cavaliers will depend upon the control under which the fire of the besieged, particularly the artillery, has been brought. When this is still somewhat formidable, the besiegers will have to give up the construction of the cavaliers, as involving too heavy a loss of time and life, and try to effect their object by small mortars throwing shells or any kind of annoying missile into the besieged works, by using small charges of powder.

137. Whichever of these means may have been adopted, the besiegers will continue their advances from the positions of the trench cavaliers either by a single branch of direct sap, or by two branches directed upon and uniting some 5 or 6 yards from the salients.

It is important to be noted, at this stage of affairs, that the besiegers must use great precautions against small sorties; by not advancing any approach much beyond the others, and by having them all well flanked and guarded by small bodies in the ends of trenches run out from them on their right and left.

138. Having in this manner reached to within some 6 yards of the crest of the covered-way bordering the ditches, and from which the scarps of the works to be breached can be seen, and their ditches commanded and enfiladed, a trench is pushed forward from each of the direct approaches parallel to and within 5 or 6 yards of the crest. As this trench necessarily leads towards the retired parts it will be more or less exposed to a commanding enfilading fire from points nearly in its line of direction, and to a slant and more or less reverse fire, from each of which it will be necessary to cover it by ordinary and wing traverses; besides which, it will be well in some cases to run out to the rear flanking ends of trenches, and when the reëntering itself is deep it may be found necessary to connect these trenches, making a continuous line or secondary parallel within the salient points gained.

139. This trench, when bordering the crest of the covered-way, is termed the *crowning of the covered-way*, and, as has been shown, may be effected either under an open assault or by a systematic approach by sap.

When the crowning of the covered-way is completed, or whilst in progress, preparations are made for constructing batteries to open breaches in the main works, and for counter-batteries to control the fire of any guns which the besieged, taking advantage of the paralysed state of the batteries in front of the 1st and 2d parallels, from the obstruction offered by the approaches in advance of the 3d parallel, and even by the parallel itself, may now put in position.

The positions given to the counter-batteries are usually such as to fire in the directions of the ditches and against the portions of the main work by which these are swept, and those of the breach batteries will be as nearly opposite as practicable to the points where it is deemed best to open breaches. The counter-batteries are thus usually thrown around the salients, and the breach batteries are placed further in, but still near the counter-batteries, as they are less exposed here to plunging or reverse fire than if placed further in. The principal point to be observed is that the breach when made shall be wide enough for the front of the assaulting column; be practicable, or of easy ascent, and open the interior of the work throughout the entire width of the breach. The wider the breach, of course the better, but one of 30 yards wide is considered a formidable gap for the besieged to attempt to close, with troops alone, to oppose an assaulting column.

140. When it is necessary to breach several points of the defences, it is best to open them all at the same time, so that by assaulting them all at the same moment, the resistance offered by the besieged may be weakened and there may be more liability to confusion. This, however, is not always practicable, particularly where a point to be breached is in a deep reëntering rendering it necessary to breach and occupy the works forming this reëntering, before the breach battery can be erected against the retired part, owing to the reverse views that the advanced parts may have upon it.

141. Whilst the breach batteries are being constructed and the breaches being made, blinded descents are made into the terre-pleins of the covered-way, at the salients, with the view of throwing up a trench in them to overlook and sweep with musketry the ditches that can be seen nearly throughout their length from these points. At the same time a descent by gallery into the ditch will be commenced at some suitable point in a direction to come out in the ditch nearly opposite the point of the breach furthest inwards, and this with a view to make the passage of the ditch upon this point of the breach where cover will be soonest obtained from the fire of the besieged still bearing on the breach through the ditch. If the counterscarp of the ditch is revetted, a gallery is extended some yards along its back, with a view to opening loop-holes through the revetment to flank the passage of the ditch. Besides this, a boyau or two may be run from the passage itself, towards the interior, to contain a few men to protect the passage from small sorties.

142. The breach may be carried either by open assault, or by a regular approach by a trench across the ditch and along up the breach, at the point above mentioned, and then by encircling the top of the breach by a trench where troops can be stationed to prevent the besieged from making any attempt to regain possession of the work after having been driven from it.

143. If an open assault is attempted, the body of troops to make it can be assembled in the galleries of the descent and from there make a rush for the top of the breach, or else a large mine may be sprung from behind the counterscarp to open a passage through which an assaulting column can rush from the trenches

into the ditch, and then make its way up the breach. In either case the operation is one of considerable danger, unless the besieged makes but a feeble resistance to defend the breach itself, and has had his fire nearly silenced.

144. The assault is prepared and conducted like all similar operations, by first bringing under all the fire of the besieged bearing on the breach and the ditch in its front, besides sweeping the breach itself thoroughly, so as to render it untenable, before the assaulting column moves upon it.

CHAPTER V.

DEFENCE.

145. THE more or less vigor with which the defence can be conducted will depend upon the strength of its artillery and its judicious employment; combined with counter approaches, sorties, and countermines to destroy the besieger's mines and render the ground, to which his near approaches must necessarily be confined, very unsafe to him.

This, like the attack, may also be divided into three periods.

FIRST PERIOD.

146. **Measures during the Investment.** During the investment, the garrison will resort to every means for cutting off parties of the investing corps which approach the work incautiously, and will particularly endeavor to prevent all attempts at reconnoitring. About one-third of the garrison will be kept on this duty, taking post as far beyond and around the work at the most secure points during the investment, and holding them as long after, as they can without too great danger.

147. As the defences at this period have no other danger to apprehend than a surprise, and nothing to annoy by their fire but reconnoitring parties, the artillery will be so posted as to be of most service in these cases. Several field guns, loaded with case-shot, should be placed in embrasure on each flank, and each face of the main work, to sweep by their fire its ditches and those of the outworks, to frustrate any attempt at a surprise; and several heavy guns with long ranges should be placed in barbette on each of the salients of the main work and principal outworks, to keep reconnoitring parties at a distance.

SECOND PERIOD.

148. Measures against the Opening of the Trenches. Whatever precautions may have been taken by the besiegers to deceive the besieged relative to the point of attack, and the time of opening the trenches, the latter, by keeping a strict watch on all the movements of the former, are usually enabled to ascertain both with tolerable certainty, and to prepare themselves accordingly. So soon as these points are ascertained with some certainty, the commanding officer, still keeping the garrison on the alert to frustrate all attempts at surprise, and without changing in any respect the artillery already in position, will place all the disposable pieces in reserve, in the best positions, on the fronts of attack and the collateral works, to do the most damage to the laborers and the guard of the trenches before they are placed under cover in the 1st parallel. Fire balls will be thrown out every night to light up the ground and ascertain the position of the laborers and troops; and, so soon as they are discovered, a heavy fire will be opened on them from all the guns that can be brought to bear on their position. At the same time a few guns will keep up a ricochet fire with shells in the direction of the capitals to annoy the workmen at the approaches.

149. Movable batteries will, if practicable, be thrown in advance of the works, in positions not to mask their fire, and near enough to open a fire of grape against the guards of the trenches and the workmen. In some two or three hours the parapet of the parallel and the trench will be in a condition to shelter the guards and workmen from this fire, when all the guns that can be brought to bear will open strongly both a front and slant fire upon the parallels and approaches.

150. Sorties. Unless the garrison is very strong, or the besiegers show a want of proper precaution in covering their laborers by a strong guard, sorties cannot be made at this period of the attack with much prospect of success, owing to the distance of the parallel from the defences. The most that can be attempted with some hope of success, is to make some charges of cavalry, to cause the laborers to abandon their work, and thus retard, for a short time, their operations.

151. Armament of Point of Attack. When, from the indications without, there is no longer any doubt respecting the real point of attack selected, all the disposable artillery will be brought forward and placed in barbette, in the best positions on this point and the collateral works, for sweeping the ground over which the trenches must be pushed. In the meantime embrasures, platforms, and traverses, should be prepared on the most suitable positions to place the artillery under shelter from the enfilading batteries so soon as they are ready to open fire.

152. Every disposable gun, except the reserve pieces, should, both at this time and whilst the besiegers' batteries are still incomplete, be placed in positions to bear upon the points occupied by them, with mortars of long range placed wherever they will be well masked and can throw their shells with the most effect against these points.

The traverses, to cover from enfilade views, should be shot-proof gabionades, and be placed so far apart only as to allow the least room for two guns between them. The terre-pleins of the barbettes should be cut down and their parapets somewhat raised, to admit of embrasures for the guns along them.

153. The fire of the defences should be concentrated on a few of the principal batteries rather than scattered over all, because, by delaying the progress of these, the others, if the besiegers act prudently, will not open their fire until all are ready.

154. Counter-Approaches. With a strong, well disciplined garrison skilfully commanded, one of the most efficient auxiliary means of defence is to be found in counter-approaches from the main defensive works on the point of attack, towards the position of the besieger's lines. These consist of simple trenches pushed forward from the most advanced works as far as can be safely done with a view of obtaining enfilading and reverse fires, both of artillery and infantry, on the trenches and batteries of the besiegers.

The front to be occupied by the counter-approaches, the distance to which they should be pushed forward in advance of the main works, and the direction they should receive, will depend upon the natural features of the site; the positions and strength of the besieger's works, and the bearing of the main defensive works upon the ground over which the counter-approaches must be run.

The portions of the besieger's works that the counter-approaches can be made most effective against, are his batteries and his boyaux of approach. Positions, therefore, should be given to the counter-approaches, and a sufficient front to obtain enfilading and slant reverse views on the boyaux with artillery and musketry, and a fire of sharp-shooters on the batteries, with a complete view of the ground in advance of them, not obstructing, however, the fire of the main defences. The trenches by which they are connected with the defensive works should be enfiladed by these, and should be so run that the retreat of the troops through them shall not be liable to be cut off, whilst they should offer a convenient and short line of communication.

To prevent them from being of immediate use to the besiegers, if carried by open assault, the reverse of the trenches, even of those which are enfiladed from the main defensive line, should receive a gentle slope to the rear to enable the trench to be swept by a slant or even direct fire from the works in the rear.

If good positions can be found for them, the counter-approaches should be supported by strong field works; otherwise stockaded keeps for small detachments may be made at suitable points to assist in repelling any open assault of the besiegers.

From the most advanced line of the counter-approaches, picked men may be sent forward to occupy good positions to annoy the artillerists and working parties of the besiegers by taking shelter behind any cover from fire or by digging holes, from which, by throwing the earth in front, they can speedily gain cover. These holes may be gradually enlarged so as to contain three or four men each, who can be readily rallied for mutual support against open assaults by small detachments of the besiegers, or for small sorties against their workmen.

The counter-approaches will also be used for positions for movable batteries of light rifled guns, which can be shifted from point to point during the day, wherever they can best annoy the besieger's works and find cover, and be withdrawn at night to secure them from the danger of capture.

During this period the engineer officers and workmen are employed in organizing the point of attack for a vigorous defence. The covered-ways are palisaded with care. Tambours, or block-houses, are established in the salients of the most advanced and exposed outworks, and also in the reënterings where guards are constantly posted.

Special attention should be paid to having ample, convenient, and secure communications between the works for the troops.

155. Daily Guard. With regard to the portion of the garrison on daily duty, the greatest number will be posted in the defences more immediately threatened by the besiegers. Detachments of some 40 men may be posted in each salient of the most advanced work of the point of attack, and 20 in salients of the collateral works, about 80 in each reëntering of these works on the same point, and 40 in each reëntering of the collateral points occupied. Besides these, there should be a detachment of about 10 men in each of the less exposed outworks of the point of attack. The number and disposition of the daily guard will, of course, vary with circumstances. The main point to be attended to is, that no part of the work, of any importance, shall be left without a sufficient force to hold the besiegers in check, in case of surprise, until support can be obtained from the main body, which last should be so distributed as to be able to carry succor promptly to any part threatened or attacked.

156. Sorties. So long as the besiegers are beyond the range of small-arms, the guards in the most advanced works have only to keep on the alert, and to send forward in the day-time a few picked men, who dig holes to fire from, or take advantage of any shelter to approach the trenches and pick off the workmen or guards who are exposed; and at night they keep out patroles to scour the ground around the work; to annoy the workmen by small sorties when an opportunity offers; and to prevent the approach of reconnoitring parties. So soon as the trenches are pushed forward within musket range of the works themselves, an unintermitted, warm fire is kept up on the workmen and guards that are exposed, some eight or ten good marksmen being placed in each salient for this service.

157. Sorties may be made with more chances of success when the besiegers commence the 2d parallel, as the guards of the trenches in the 1st parallel are not so near at hand to protect the workmen as during the construction of the trenches up to this point.

The detachment for the sortie, consisting of several hundred infantry, will sally from the most advanced works to attack the

2d parallel on one or both flanks, and, if circumstances favor, in front. When the workmen are put to flight, instead of pursuing them, the detachment will form in battle order to cover a party of some hundreds of workmen, who follow in rear of the detachment, whilst they are filling up the trenches, destroying the implements, and setting fire to the gabions. The working party will be also covered on each flank by a detachment of infantry and all the disposable cavalry of the place, and with one or two batteries of light field guns manœuvring with the cavalry. When the guards of the trenches appear in force to repulse the sortie the troops will retreat slowly, without compromising their safety, and will endeavor to draw the troops in the pursuit within short range of case-shot of the works, a fire of which will be opened on them so soon as the retreating troops are out of danger from it. This operation, if successful, may be repeated several nights in succession; the best moment is just before dawn, when the guards of the trenches are fatigued and sleepy with watching. Although the chances of success are greater at this stage than at the opening of the trenches, still, if the besiegers take proper precautions, the sortie will, in all probability, prove more prejudicial than advantageous to the besieged.

158. **Distribution of Artillery.** Before the besiegers open the fire of the enfilading batteries, the fire of the defences will be concentrated, as has been said, on the principal of these, and will be kept up against them until a marked effect is observed in the fire of the enfilading batteries. Only one gun will then be left between each traverse on the faces of the defences, the others being withdrawn and kept in reserve. The guns kept in battery will fire steadily upon the heads of the approaches as they are gradually advanced.

THIRD PERIOD.

159. **Distribution of Artillery.** After the 3d parallel is constructed the guns may be replaced with advantage by stone and Coehorn mortars, firing from sheltered positions in the most advanced works. Guns will be placed in embrasures to fire in the direction of the ditches of these works and to sweep their terre-pleins and the ground in advance of them.

160. Gun Shelters. At this stage the musketry fire of the besiegers becomes very destructive to the artillerists of the defences whilst serving the guns. Strong iron or oak musket-proof blinds should be arranged to mask the mouths of the embrasures when the guns are not in battery. Blinds, or covers of timber and earth under which guns can be secured from projectiles that would reach them at top or in flank, will now be serviceable. A few guns covered in this way, and placed in the salients of the collateral works, to obtain reverse views on the trenches constructed on the glacis of the works, will prove a serious annoyance to the sappers, and will greatly retard their progress.

161. Distribution of the Daily Guard. The troops in the most advanced works will keep up a warm fire of musketry against the heads of the sap, and on every exposed point. The men whilst firing occupying points where they will be well sheltered and can best see the leading sappers. A few marksmen will also occupy the parapets of the other works to keep up a fire from them, but only during the day, as at night this fire might injure the men in the most advanced works.

The greater part of the guards of the least secure of the advanced works should now be withdrawn at night and be posted on more secure points, so as to expose but few troops if an open attack is made.

162. Small Sorties. Although sorties in large bodies seldom prove successful after the 2d parallel is finished, those made by small detachments of from ten to forty men against the head of a sap, or other work, when the besiegers are advancing beyond the 3d parallel, will seldom fail if conducted with proper precautions.

This method of annoyance wlll be particularly serviceable during all the subsequent stages of the defence, as the besiegers cannot now have at hand a very large force.

163. Defensive against Gradual Approaches. The defence of the most advanced works will be regulated by the method pursued in the attack. When the latter is made by gradual approaches, the troops, with the exception of a few men who can find a shelter behind traverses or other covers, will be withdrawn from the salients, so long as these are annoyed by the fire of the stone mortars; when this fire ceases, which usually takes place when the sap is pushed well forward from the 3d parallel, the troops again enter the salients and renew their fire on the heads of the sap, directing it particularly against the sappers working at the trench-cavaliers. When the trench-cavaliers are completed and armed, the troops again retire from the salients and occupy the traverses and other shelters where they maintain their fire, and throw hand grenades on the sap when it comes within their range. Stone and Coehorn mortars are also placed behind the traverses to annoy the sap, etc.

164. Defensive against Open Assault. If the besiegers are observed to be making preparations to attack by open assault, no more troops than will be required to line the parapet of the work threatened should be posted in the more salient parts, and they should maintain their position no longer than is necessary to give the storming party one volley as they débouche from the 3d parallel; retreating immediately after to the main ditch, or to other designated points. A reserve of about one hundred men is posted in each reëntering part occupied by the guards to cover the retreat of those from the salients. All the other works are lined with troops, and such guns as can still be brought to bear on the glacis, loaded with case shot, open, at the same time with the infantry, a deadly fire on the storming party, which is kept up until the assailants are either driven from the work assailed, or take shelter in the trenches constructed by the sappers along the crest of the glacis. A vigorous sortie both on the front, the flanks, and the rear of the storming party, made from the collateral advanced works, will in such cases be a judicious operation.

165. Distribution of Artillery against Breaching Batteries. As the moment for erecting the breaching batteries approaches the efforts of the besieged will be redoubled to retard the works of attack. Independently of the measures already laid down the besieged will arm with artillery the flanks which bear on the point of attack, and will construct oblique embrasures in the reënterings like the curtains to sweep the positions along the salients, where the besiegers are making their breach and counter-batteries. The guards of the covered-way will retire towards the reënterings as the crowning of the salients advances, disputing the ground foot by foot, and holding possession of each point until the besiegers are nearly in a situation to envelope it with their works. The stone and Coehorn mortars will be removed to the reënterings, or into some of the communications in the rear, from which a fire can be kept up on the trenches. In fine, every possible means will be resorted to, such as rolling over grenades, loaded shells, fire balls, etc., by which the sappers constructing the breach batteries and the descents into the ditches can be cut off and their labors be retarded.

166. **Defence of the Ditches.** When the besiegers have established themselves so strongly around the point of attack that sorties in small parties cannot be made without too great risk, a warm fire of musketry will still be kept up on the trenches from all the out-works, and the besieged will wait until the descent of the ditch is opened through the counterscarp wall before renewing the same game of sorties in small parties. A vigilant look-out will be kept to ascertain this moment, and, so soon as the sappers show themselves, every effort will be made to cut them off, and destroy their work, by opening a fire both of artillery and musketry on the opening; by sorties in small bodies, and by throwing loaded shells, grenades, etc., into the ditch.

167. In wet ditches filled with stagnant water, the besieged will resort frequently to night attacks in boats on the dike or passage made to cross it; and in the case where water can be suddenly let into or be drawn from the ditch, chases of water will be used to sweep away the besiegers' works.

168. **Defence of Breaches.** In defending the breach of any work, the besieged will resort not only to the fire of any interior defensive work, but will erect barricades on the right and left of the breach, across the terre-plein, from which a warm fire of musketry will be poured in on the besiegers whilst they attempt to gain possession of the breach either by gradual approaches or by storm. Small mines, bomb or stone fougasses, should be prepared at the summit of the breach to be exploded so soon as the besiegers gain possession of it. The top of the breach will be strewn with every possible obstacle that can retard the progress of the storming party, and grenades, thundering barrels, etc., will be rolled over on the troops whilst mounting the breach.

169. The measures for the defence of the main ditch and of the breach in the main work, differ in nothing from those resorted

to for the out-works. The besieged will make every effort to keep possession of the main ditch to the last moment, by occupying the double caponnières and other works in them, from all of which a steady fire will be kept up on the besiegers whilst effecting the passage. Sorties of small bodies of picked troops will be frequently made under the protection afforded by these works, etc. The posterns at this period require to be guarded with peculiar vigilance to prevent the besiegers carrying them by surprise, and thus effecting an entrance into the interior of the work.

170. An assault of the main breach cannot be opposed by the bayonet without compromising the lives of the garrison, unless there exists a good interior retrenchment to cover the retreat from the breach; even in this case, to oppose the storming party with the bayonet will be an operation of great delicacy, for the besieged, if driven back, may not be able to effect their retreat without being so mixed up with the assailants as to render it impossible to prevent the latter entering with them into the retrenchments.

171. Finally, when the breach is effected in the interior retrenchment the besieged may offer to capitulate, unless they are still able to protract the resistance a day or two, by organizing temporary defences, and by placing the houses in the rear of the retrenchments in a defensive state, in which cases this breach should be disputed with the same obstinacy as those of the other works.

CHAPTER VI.

PLAN AND JOURNAL OF THE ATTACK.

As an illustration of this subject, the mode of conducting the attack, as laid down by Vauban and his successors, in the hypothetical case of a bastioned main work with all the ordinary outworks on a horizontal site, will now be described.

The point of attack selected (Fig. 32), being an acute bastion, X, having an interior commanding retrenchment, with the two adjacent demi-lunes, Y. The only collateral works, the fire of which bears on the ground over which the trenches must be run, being the two adjacent obtuse bastions, W, the faces of which cannot be enfiladed, owing to their prolongations falling within the salients of the adjacent demi-lunes, and the two collateral demi-lunes, Z. Making in all one bastion and the two adjacent demi-lunes, with their dependent out-works, which must be entered by breach or otherwise; and two bastions and two demi-lunes, with their dependent works, the fire of which must be kept under.

From the disposition of the defensive works, at least three lines of approaches, one on the capital bastion of attack, and one on each of the capitals of the adjacent demi-lunes, will be requisite as communications; and the 1st and 2d parallels will be required to be extended so far on each side of the point of attack as to embrace all the positions for the enfilading and counter-batteries to keep under the fire of the works collateral to the point of attack, which in any manner bears upon the ground to be occupied by the approaches.

The rules for laying out the approaches, being that they should be run in zigzag lines across the capitals, gradually narrowing the front occupied by them as they near the salients of the point of attack, and giving to each branch a direction such that it cannot be enfiladed from any salient point of the collateral works, will be complied with, by confining each branch between two lines, one on each side of the capital, which starting from points on the 1st parallel, 30 yards from the point where the capital crosses it, converge on points 15 yards on each side of the salient approached; the direction given to each branch being such that prolonged it would pass 30 or 40 yards exterior to the most advanced salient. In following this rule it is advisable that no branch should exceed 100 yards in length, otherwise the besieged might be tempted to run out a counter approach to enfilade it.

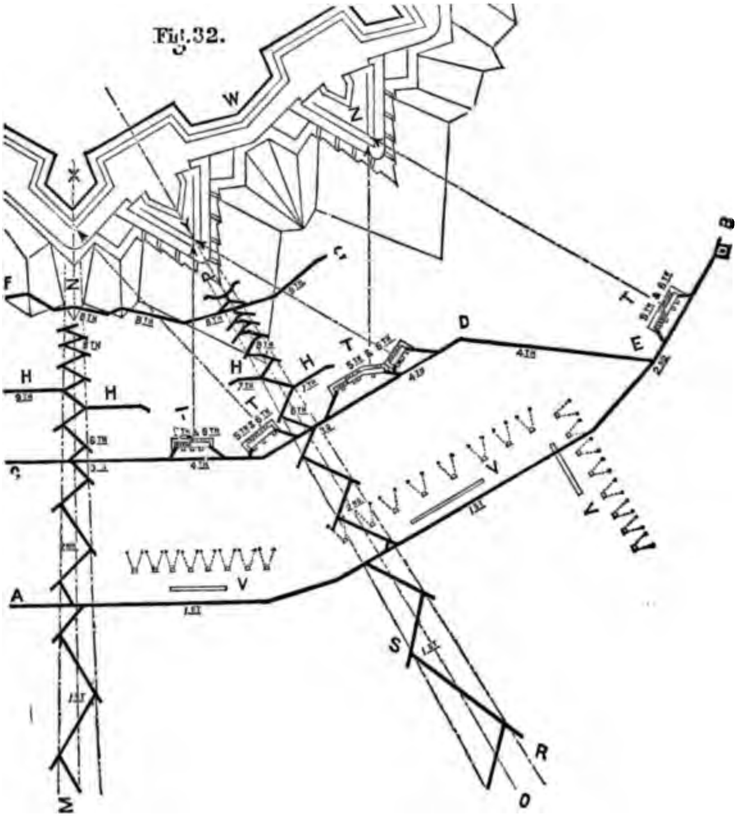

Fig. 32. Plan of Defensive Works and of the Regular Approaches against them during the 2d Period of the Siege Operations. W X, etc., Main Work; Z Z, Out-works; M N, O Q, Direction of the Approaches on two of the Capitals; A B, 1st Parallel; C D, 2d Parallel; D E, Trench connecting 1st and 2d Parallels; F G, 3d Parallel; H H, Demi-parallels; T T, etc., Enfilading, Counter, and Mortar Batteries; R S, Direction of a Boyau of the Communication between the Depôt of the Trenches and the 1st Parallel.

The communications leading from the depôts of the trenches to the 1st parallel, will be laid out along the same lines and in a like manner.

The position of the 1st parallel will be assumed at 600 yards from the most advanced salients of the point of attack and collateral works.

1st Night. The position of the portion of the trenches upon which the besiegers are to break ground having been laid out, and the materials for the work having been placed in order for distribution, so as to avoid all unnecessary delay and confusion, the workmen are assembled at the depôts of the trenches before night-fall to receive their implements. The men selected for this duty are troops of the line, who usually take their arms with them. The men are divided into working parties, each of which is under the command of an officer of the line, and they are marched in single file by a flank and posted after night-fall, where they are to work under the direction of the engineers.

The portion of the trenches opened this night are, usually, only the approaches that lead from the depôts of the trenches to the 1st parallel, and that portion of this parallel which embraces the capitals of the point of attack. To guard the workmen from sorties, as many battalions of the line as may be requisite, termed the *Guards of the Trenches*, are thrown forward about 30 paces in advance of and on the flanks of the men who open the 1st parallel. The flank companies of these battalions, divided into sections, cover the front of the battalions, and are posted about 30 paces from them; and each section posts two sentinels at about the same distance to its front. The sentinels keep a look-out, kneeling on one knee; the remainder of the troops lie flat on the ground, to avoid the fire of the defences.

When the working parties are all posted, the men of each lying flat until all are ready to commence the work, the order is given to rise, ground their arms a few paces to the rear, and break ground.

The guards of the trenches keep their position until near dawn, when they are withdrawn and take post in the parallel, which, by this time, will be nearly excavated to its full width.

On the succeeding day all that remains to be done to the trenches opened is completed, and everything is got in readiness for the work of the coming night.

2d Night. The parallel will be extended this night to embrace the prolongations of all the faces to be enfiladed, and some 100 or 150 yards beyond the extreme points so determined. A strong square redoubt will be constructed at each extremity of the parallel, which will be armed with field pieces; and an epaulment for cavalry will be thrown up in the rear of each redoubt; the object of these works being to contain troops to act against sorties made on the flanks of the parallel.

The zigzags are pushed forward about 150 yards in advance of the 1st parallel.

The trenches and other works left incomplete at the end of the 2d night are finished on the following day; and this rule is followed throughout, as the trenches commenced by night are generally in a suitable state by dawn to give cover to the workmen and troops and can be occupied, and what remains to be done to them be completed in safety by day.

3d Night. The approaches are pushed forward 275 yards from the 1st parallel, and here the 2d parallel is commenced; a small portion of it only on each side of the approaches being opened, in which to lodge a few troops for the protection of the workmen.

This parallel is of less extent than the 1st, embracing only the prolongations of the faces of the Point of Attack. It is usually connected with the 1st parallel by a defiled line of trench at each of its extremities. Its distance from the 1st is determined from the consideration that the workmen employed on it must be protected by the guards of the trenches, who are still stationed in the 1st, and who, to afford this protection, should be posted where they can come to the aid of the workmen before the garrison can reach them in a sortie.

The rule here observed is also a general one. The trenches under construction never in any case being advanced so far that the guards in their rear cannot come up to their support before they can be reached by a sortie from the defences.

4th Night. The 2d parallel is entirely laid out on this night and is completed on the following day. The guard of the trenches takes post in the parallel as fast as a part of it is finished; a reserve equal to about one-third of the whole being left in the 1st parallel.

As the 2d parallel is at 325 yards from the salient of the place, the workmen are much exposed to the fire of grape shot, it will therefore be necessary to use the flying sap in its construction.

5th and 6th Nights. Thus far the works of the attack have been pushed forward without the aid of artillery, but beyond the 2d parallel the fire of the defences becomes so destructive that further progress cannot be made, without great sacrifice of life, until it is silenced. To effect this, enfilading, mortar, and counter-batteries are placed about 30 yards in front of the parallel. The number of guns in each battery will depend on the importance of the face to be silenced, and, according to this rule, the following distribution will be made.

A battery of eight pieces will be erected against each face of the bastion of attack. A battery of five pieces against the right face of the demi-lune of attack and its covered-way, and one of seven pieces against the left face, since the fire from the latter bears more directly on the approaches than that of the right face. As the two collateral bastions are supposed to be so obtuse that their faces cannot be enfiladed, it will be necessary to silence their fire by counter-batteries. As the left face alone of the bastion, on the right of the one of attack, has a direct action on the approaches, a counter-battery of five pieces is erected against it, and so placed as to obtain a slant fire into its embrasures. With regard to the collateral demi-lune on the same side, as its right face has but a slight bearing on the approaches, a battery of three pieces will prevent this face from being occupied by the besieged; but as the bearing of its left face is more direct, it will be necessary to establish a battery of five pieces against it; this last battery is placed in front of the 1st parallel. Two or three howitzers form a part of each battery to sweep the covered-ways and ditches.

The mortar batteries are placed in positions where they will be most effective, which is usually about midway between the capitals of the works to be reached from them. About four mortars are placed in each battery, an allowance of eight mortars being made for each front embraced by the trenches.

The mortar and gun batteries, the fire of which is not obstructed by the trenches in front of them, are sunk. The platforms of the others are on the natural surface of the ground.

Besides these batteries, which will be completed on the 5th and 6th nights, two or three zigzags are pushed forward in advance of the parallel on the same nights, if the fire of the besieged is not too destructive.

7th Night. As the enfilading batteries will be completed and armed on the 6th night, on the following morning they will all open their fire at the same moment, and by night the fire of the place will be nearly if not entirely silenced. The approaches are then pushed forward and demi-parallels are established at from 100 to 150 yards in front of the 2d parallel. The demi-parallels may be from 100 to 200 yards in length, and have a return of 25 yards at their extremities to cover them on the flank. The length of the demi-parallel should be so regulated as not to obstruct the fire of the ricochet batteries. In some cases howitzers are placed in batteries established at the extremities of the demi-parallels to enfilade the covered-ways, but as the demi-parallels are within good musket range of the covered-ways it will generally be better to arm them with infantry, the top of their parapet being arranged with loop-holes made with sand-bags to cover the marksmen whilst in the act of firing.

8th Night. (Fig. 34.) On this night the approaches are pushed forward by the flying and full sap, as opportunity may offer, and a portion of the 3d parallel is commenced, when the approaches are within 60 yards of the most advanced salients.

9th Night. The 3d parallel is completed. It should present a less development than the 2d so as to be flanked by it, and will therefore usually embrace only the salients of the point of attack. Owing to this, and its having to receive the main body of the guard,—the 2d parallel now containing only the reserve, whilst the 1st is used only as a depôt for the materials and to receive the wounded,—the third parallel is made two or three feet wider than the other two.

10th Night. As the 3d parallel, from its position on the glacis, will mask the fire of the ricochet batteries against the covered-way, it will be necessary to establish new batteries in front of it to dislodge the besieged from this outwork. For this purpose stone mortar batteries are found very effective. These batteries are placed at about 20 yards in front of the parallel, and are sunk. A battery of four or six mortars is placed on each side of the salients, nearly in the prolonged direction of the covered-ways. These batteries will be ready to commence their fire on the covered-ways on the morning after they are begun.

After the completion of the 3d parallel, preparations are made for gaining the covered-way either by open assault, or by gradual approaches. In the former case, portions of the parallel are arranged with steps to enable infantry to sally from it on the covered-ways. The sappers, with all the necessary materials for trenching around the covered-way, are collected in the parallel. At a pre-concerted signal a fire will be opened from the stone mortar batteries, and all others that are still effective, against the covered-way, and the other out-works. When it is perceived that the fire has produced its effect in clearing the out-works, at a preconcerted signal it will also cease; the troops will sally forth and carry the covered-way with the bayonet, and, after gaining possession of it, they will shelter themselves as they best can behind the traverse from the fire of the besieged. Whilst

Fig. 33.

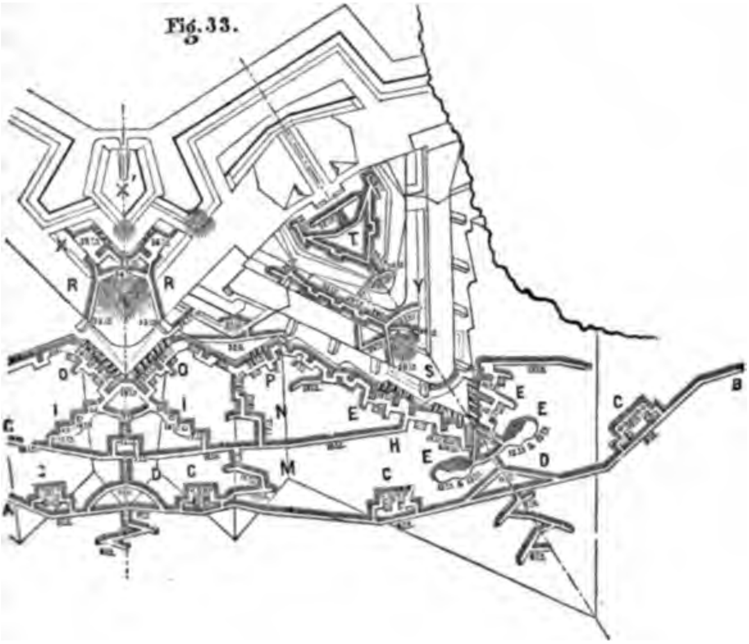

Fig. 33. Plan of Approaches during the 3d Period. A B, 3d Parallel; C C, etc., Stone Mortar Batteries; D D, Circular Places-of-Arms; E E, Trench Cavaliers; G H, 4th Parallel; F F, Breach and Counter-batteries against the Demi-lune and the Bastion Faces; O O, Breach and Counter-batteries against the Bastion, X, and the Bastion Flanks; P, Breach Battery against the Redoubt of the Reëntering Place-of-Arms; R R, Passage of Main Ditch; S, Passage of Demi-lune Ditch; Y, Trench to secure top of Demi-lune Breach; T, Works to secure Demi-lune Redoubt; X', Interior Cavalier Retrenchment of Bastion.

they, in this way, maintain possession of the covered-way, the sappers, who follow immediately in their rear, will open a trench about 4 or 5 yards from the crest of the glacis, around the salient place-of-arms, as far as its two traverses; when this trench will afford a shelter to the troops they retire from the covered-way into it. This trench is afterwards connected by suitable communications with the 3d parallel.

From the circumstances under which this operation is carried on, the probabilities are against its success and in favor of a great sacrifice of life in the attempt if the besieged offer a vigorous resistance, and make a skilful use of the means still at their disposal. With such chances, therefore, of failure, and the certainty of great losses even if successful, this mode of attack should only be resorted to in some contingency where the success of the siege depends on the time saved by it.

11th Night. When the covered-way is to be crowned by regular approaches, a constant fire is kept up from the stone mortar batteries so as to render it untenable for more than a very few men. The *Circular Place-of-Arms* which serves mainly as a depôt for the trench materials and thus to keep the 3d parallel from being obstructed, is now formed, by starting from two points of the parallel at 30 yards on each side of the capital, and pushing two branches of full sap to unite at about 15 yards from the parallel, on the capital. From this point a double sap is pushed along the capital to within 30 yards of the salients of the demi-lune covered-ways. As the bastion covered-way is very retired, nothing more is done than to form the circular place-of-arms before it.

12th Night. The trench cavaliers before the demi-lune salients are commenced, and the sap is pushed forward a few yards on the bastion covered-way.

13th Night. The trench cavaliers, which require from 36 to 48 hours for their completion, will be finished on this night, and an approach pushed from the stone mortar batteries towards the reëntering place-of-arms.

14th Night. The besieged being now driven from the covered-ways by the fire of the trench cavaliers, a double sap is pushed towards the salient of the demi-lune covered-way from the two extremities of the circular trench connecting the trench cavaliers. These two saps unite at 4 or 5 yards from the crest of the glacis.

The approaches towards the reëntering place-of-arms are advanced further on.

15th Night. The demi-lune covered-way is crowned as far as the 2d traverse. The approaches on the reëntering place-of-arms and the salient of the bastion covered-way are advanced.

A 4th parallel is begun on this night, commencing opposite the 1st traverses of the demi-lune covered-ways, and uniting the approaches pushed towards the reëntering places-of-arms.

16th Night. The breach and counter-batteries around the salient place-of-arms of the demi-lune are completed and armed.

From four to five guns will be placed on each branch of the glacis of the salient place-of-arms, in the prolongations of the demi-lune ditch, to counter-batter the portions of the bastion faces which bear upon this ditch and the covered-way, and prevent this fire from retarding the lodgments about to be made on the terre-plein of the salient place-of-arms and the passage of the ditch. About four guns are placed in a battery between the 1st and 2d traverses, to open a breach in the left face of the demi-lune. This breach should be from 20 to 30 yards in width, and not extend farther towards the salient than the position of the pan-coupé, so as to expose as great an extent of the interior of the demi-lune as practicable.

The guns in these batteries will require cover in flank from the faces of the bastions and their cavaliers; and in rear from the most advanced salients of the works still occupied by the besieged.

The descent into the demi-lune covered-way, commenced on the 15th night behind the 1st traverse, is finished; and the 4th parallel is completed. The width of the 4th parallel is the same as an ordinary approach, owing to the difficulty of defiling it.

These batteries will be completed and armed in twenty-four hours after the crowning is commenced. The breach will be practicable in twelve or fifteen hours after the fire is opened.

17th Night. The approaches from the 4th parallel are pushed forward on the salients of the bastion covered-way and the reëntering place-of-arms. The crowning of the demi-lune covered-way is gradually advanced and a lodgment is made on the terre-plein of the demi-lune salient place-of-arms, from which the demi-lune ditch can be swept by musketry.

The descent into the demi-lune ditch is commenced on this night behind the traverse of the salient place-of-arms.

In advancing the sap on the different salients of the covered-way, from the 4th parallel, care should be taken not to push forward one faster than the others, so as not to offer a temptation to the besieged to sally out on the head of the most advanced, to cut off the sappers. Moreover, the different brigades of sappers should be protected by a few picked men stationed in short trenches that flank the direction of the double sap as it is pushed forward on the salients.

If, owing to the great width of the covered-way, or to the small breadth of the demi-lune ditch, or to the steepness of the glacis, by which the batteries placed along its crest would be very much exposed to a reverse fire from the collateral works, it should become necessary to place the breach and counter-batteries on the terre-plein of the covered-way, they cannot be completed and armed before the 17th or 18th night. Although the batteries in this position would be well covered from reverse fire by the crest of the glacis, and from a flank fire by the traverses of the covered-way, still, they would require much more labor to establish them, and would be more exposed to the annoyance of grenades thrown from the demi-lune.

After the descent into the demi-lune ditch is commenced it is steadily carried forward until it arrives at the point opposite the breach, where the opening into the ditch is to be made through the counterscarp wall. This opening should be pierced at night, and the precaution should be taken to run a small gallery along the back of the wall, on each side of the opening, so as to place a few men to fire through loop-holes made in the wall, for the purpose of defending the opening and the sap pushed across the ditch to the breach.

18th, 19th, and 20th Nights. The approaches from the 4th parallel and the sap along the crest of the covered-way are pushed forward and completed on these nights.

It will seldom be practicable to establish a trench cavalier against the bastion salient place-of-arms, owing to the reverse fire from the collateral demi-lunes. In such a case, if the besieged still occupy this work in force, so as to retard the progress of the sap, an attempt must be made to dislodge them by an open attack of a small party of picked troops, or else stone mortar batteries may be placed in the position that would be occupied by the trench cavaliers, by means of which the besieged may be driven from this part of the covered-way.

So soon as the bastion covered-way is gained, two descents are commenced into the main ditch, from the trench at the salient of the covered-way.

In very acute bastions the breach and counter-batteries along the bastion covered-way might be completed on the 21st night. But, generally, before this can be done the demi-lunes must be carried, as their fire would take these batteries so in reverse as to render their construction impracticable.

25th Night. The descent into the demi-lune ditches and passage of the ditches may be effected by this night at farthest.

Every precaution should be taken to prevent the besieged from interrupting this passage. The passage itself should be 4 or 5 yards wide at bottom, to afford a convenient place-of-arms for the troops, and it should be arranged with a banquette to sweep the ditch by a close musketry fire.

Besides making loop-holes in the counterscarp wall to flank the passage, it will also be well to push forward one or two zigzags in the ditch itself, and place a small party of picked men in them to repel the sorties of the besieged.

The breach is gained possession of either by storm or by gradual approaches. The former will be resorted to when the besieged manifest a determination to keep possession of the demi-lune, in force, to the last extremity. A few companies of picked men will be chosen for this service. All the materials will be collected at hand for crowning the breach, and, when everything is in a state of readiness, a warm fire will be opened on the breach and on all the works that in any way bear upon it. At a preconcerted signal the fire will cease, and the assaulting column, rushing through the breach, will drive the besieged from the demi-lune, and then, sheltering themselves as they best can from the fire of the other works, they will maintain possession of the breach until the sappers, who follow in their rear, can effect a lodgment on its top.

To make the lodgment by gradual approaches, the sappers will push forward a sap from the foot of the breach, over the ruins, giving it such a direction as to gain a shelter under the end of the wall that remains on the side of the breach which is exposed to the fire of the besieged. A few picked men will cautiously mount to the summit of the breach, occupying such sheltered points as may be found at hand, for the purpose of covering the sappers whilst at work. These men will be sustained by a detachment posted along the passage of the ditch.

26th Night. The lodgment on the breach of the demi-lune being effected on this night, the breach and counter-batteries along the bastion covered-way, and against the redoubt of the reëntering place-of-arms, can be completed and armed.

A breach battery of four guns will be placed along each crest of the bastion covered-way, as far from the salient as room can be had, for the purpose of opening as wide a breach as practicable at the bastion salient. A counter-battery, likewise of four guns, will be placed along the same crest and in the best position to fire in the prolongation of the main ditch and silence the fire of the enceinte flanks opposite to them. A breach battery of three guns will also be placed against each of the redoubts of the reëntering place-of-arms, to open them on their faces that lie adjacent to the demi-lunes.

These batteries are covered in flank and rear in the same manner as those against the demi-lune.

To prevent the besieged from attempting to dislodge the besiegers from the demi-lune, it is well to construct a trench across its terre-plein, from which the ditch of the demi-lune redoubt can be swept by a fire of musketry. This trench may be made on the 27th night.

So soon as the demi-lune breach is secured a descent is commenced from the lodgment on it to the ditch of its redoubt.

This descent and the passage of the ditch of the redoubt will take until the 32d night.

In the meantime zigzags can be pushed forward in the demi lune ditch; and a double sap be formed in the parapet of the demi-lune itself, to overlook the ditches and to approach the cut in the demi-lune face.

A descent can also be made on or before the 32d night into the reëntering place-of-arms, and a lodgment be effected on its terre-plein.

On the 32d night, miners are set to work at the scarp wall of the demi-lune redoubt, and at the scarp and counterscarp walls of the cut. The mines may be completed and fired and the lodgment be effected on the breaches by the 34th night; at which time the breach in the redoubt of the reëntering place-of-arms is also carried.

When a breach can be opened in the bastion face through the opening of the demi-lune ditch, the zigzags in this ditch may be pushed forward nearly to the extremity of the ditch, and the passage of the main ditch opposite the breach in the salient be effected by the 33d night, so that the breaches in the body of the place, and those in the redoubts and the cut can all be carried on the 34th. But when a breach cannot be made in the face of the bastion through the demi-lune ditch, and it is deemed advisable to make one at this point, it will be necessary to carry the outworks first, and afterwards to push forward the sap to crown the glacis of the single caponnière in the demi-lune ditch, where a breach battery of two guns may be established; at the same time a lodgment is made behind the bastion covered-face and a breach battery of four guns is established there. These labors will require for their completion until the 37th night. In the meantime lodgments are effected on the upper and lower terre-pleins of the demi-lune redoubt, and in its parapet, to overlook the main ditch, the double caponnières, and the tenailles.

The passages across the main ditch are also completed, the descent to the one nearest the shoulder angle being commenced from within the postern of the redoubt of the reëntering place-of-arms.

34th Night. The lodgment on the breaches in the bastion will be effected on this night, and a descent be commenced from the top of the breach to the ditch of the cavalier.

35th and 36th Nights. A lodgment will be effected on the bastion terre-plein, and a breach battery of four guns be established against each face of the cavalier retrenchment.

The descent into the cavalier ditch will be effected by the same time, and the final assault take place on the 37th night.

CHAPTER VII.

ILLUSTRATIONS OF SIEGE WORKS FROM SOME OF THE MORE RECENT SIEGES.—SIEGE OF SEBASTOPOL.*

THE remarkable defence of this place by the Russians has made it a striking event in siege operations, for the immense material means employed on each side, and for the skill and indomitable resolution of both the assailant and the assailed, shown during eleven months of open trenches, from Oct. 7th, 1854, when ground was first broken before it, until Sept. 8th, 1855, when the final successful assault was made. But what distinguishes this from most other celebrated sieges, was the comparatively slight and temporary character of the besieged works; the side of the place where the Allied forces made their attack having no permanent defences of any value, but only a line of earth works hastily thrown up, and of comparatively so weak a profile as, under ordinary circumstances, to have yielded to a vigorous *coup de main.*

As any attempt at a description of this important position and the siege operations on both sides could be made intelligible only by the aid of detailed maps and plans, a few observations must suffice as to the causes which enabled the Russians, behind such weak defences, to retard for so long a period the regular approaches of the Allies; repulsing them in one open assault, and finally succumbing in a second only after a desperate resistance, and inflicting on the assaulting columns the heavy loss of over ten thousand in killed and wounded.

1. Being the great naval arsenal of the Russians in the East, Sebastopol had a superabundance of everything in the way of

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* Siége de Sébastopol. Journal des Operations du Génie, par le Général Niel. Paris, 1858.

Siége de Sébastopol. Histoire du service de l'Artillérie. Paris, 1859.

Siege of Sebastopol. Journal of the Operations conducted by the Corps of Royal Engineers; and Professional Papers of the Corps of Royal Engineers. Vol. VI. New Series.

arms and munitions of war for a siege, which had been accumulating there for a long time for the service of the navy.

2. It had a large army to garrison it, and to make formidable assaults upon the besiegers, who had not sufficient force to invest it on all sides and therefore left it free to receive succors.

3. It had the aid of the sailors and the resources of a large fleet which was shut up and kept idle in its harbor by the superior strength of the Allied fleet.

4. The topography of the position was very favorable to the defensive, both in the laying out of the defensive works and in the obstacles it opposed to the siege operations of the Allies.

5. The late period of the year when the Allies commenced their siege operations, and their want of adequate means for some time after to do more than hold their position; owing to this want, to the inclemency of the season, and to the sickness among their troops.

6. Though last, yet not the least important, the skill and untiring energy shown by the Russians in availing themselves of every means to retard the operations of the Allies.

In mere engineering details, the Russians have through this siege added but little to the general stock. Their works were generally well adapted to the ground occupied by them, and in good defensive relations; such as the position itself would naturally suggest to an engineer acquainted with his art. Unprovided with permanent bomb-proof shelters for their troops, who were constantly exposed to a terrific fire, they constructed temporary ones from the large quantity of heavy timber they had in their dock-yards, placing them in the traverses of their works and wherever else was found most convenient. From the same source of supply, they obtained the rope of which they constructed the heavy mantlets to shelter their artillerists from the enemy's sharp-shooters. They employed with great effect their own sharp-shooters, lodging them in rifle pits and trenches in advance of their line to retard the besiegers' works. They employed with great advantage the means of counter approaches, and the occupation by temporary works of points considerably in advance of their principal line of defences, which caused great annoyance and loss to the besiegers. Besides their carefully aimed fire, they resorted to random firing of both cannon and small-arms under high angles of elevation, particularly where an enfilading view of a line of trenches could be obtained, which produced considerable annoyance and loss to the laborers in the trenches, and in many instances forced the besiegers to increase the height of the parapets and traverses of their batteries, and to take other extra precautions to give shelter to their men and guns. As has been previously stated, their mining operations were very extensive and greatly delayed the French in their approaches on Bastion No. 4, and, had they been as timely and successfully employed in advance of the Malakoff fort, might have caused a still more serious delay to the Allies. In their sorties against the besiegers' works the Russians did not succeed as well as might have been looked for from their large garrison. This want of success, Marshal Niel, who directed the final siege operations of the French, attributes to these sorties having been made by night, which, from obvious causes, greatly increases the chances of failure, particularly in such broken ground as that in advance of Sebastopol. Marshal Niel is of opinion that had the sorties been made by day the chances would have been greatly in favor of them, owing to the small number of troops that the Allies were able to keep near their points of attack; the separation of these points by deep and difficult ravines, which prevented a coöperative defence; and from the great distance in rear of the main body of the army, to place it out of the long range of the heavy guns of the place; all of them circumstances greatly in favor of a more active system of defence than the Russians attempted.

The Allies, after taking up their position in front of the place, covered it from attacks to which they were exposed by a succoring force from without, by throwing up a line of circumvallation partly continuous and partly of detached works; and, at a somewhat later period of the siege, strong continuous lines of field works in their rear to cover the two harbors in which their fleets lay.

After opening their first parallel, which was from 1,000 to 1,300 yards from the points to be approached, the trenches were pushed forward and batteries established in the best positions for controlling the fire of the defences according to the usual siege practice. The besiegers here labored under the great disadvantage of having to sap through ground more or less stony, and in some places over a bare rock, and for a considerable portion of the siege, in the face of a fire superior to that of their own batteries, by which their trenches at points were frequently swept away and their work brought to a stand-still.

In conducting the labors of the trenches and batteries, no noticeable changes of any moment in the usual practice were made but such as were imperatively demanded by the circumstances of the locality; it being often foun dimpracticable to give to the trenches and their parapets the dimensions usually considered as desirable, and every expedient had to be adopted, where adequate cover from fire could not be given, to screen the men at least from the view of the besieged. Although in the execution of the full sap the French sappers suffered very much from the Russian sharp-shooters, they preferred abandoning all the usual defensive armor, on account of the greater fatigue in laboring with it on.

The batteries, as being a more certain mark for the fire of the besieged, were constructed with every care to make the parapets shot-proof, and their magazines and shelters for the men and loaded projectiles bomb-proof. In some cases of more than ordinary exposure to the fire of the heavy calibre used by the besieged, the parapets of the batteries received a thickness of from 23 to 26 feet; the thickness most generally given being 20 feet.

Every expedient was tried by the French to damage the besieged, amongst others that of an abundant use of small mortars of 6-inch calibre, which, from their lightness, could be easily carried by a few men and placed in any work of the trenches from which the besieged could be best reached by their shells. Random firing at long ranges and under high angles of elevation, by cannon, was also tried with good results. For this purpose the platforms were so arranged that the wheels ran upon side rails about 14 inches above the level of the platform on which the trail rested, thus giving the facility of firing the gun under much greater angles of elevation than upon the ordinary level platform. Some attempts were made at throwing wooden vessels made of thick staves and strongly hooped, and containing about 200 pounds of powder, named by the French *mines de projection*, into the defences, from funnels in the earth similar to those used for the stone fougasses, and subsequently by fastening them to the mouths of large mortars, but the experiment not answering expectation it was given up. The use of the stone fougasses loaded with fragments of stone, iron, etc., was found to be of great advantage in reaching the besieged behind their parapets and traverses.

To cover the men working in the trenches from the annoyance of the sharp-shooters of the besieged who, either from their advanced rifle pits, or from favorable covers offered by the ground, kept up a very deadly and incessant fire, the French in turn organized companies of sharp-shooters, and placed them in rifle pits in advance of the ground on which they were working to keep down this fire, and as opportunity offered to make a dash upon and seize these covers of the besieged.

In the early period of the siege, the French met the frequent sorties of the Russians by advancing upon them beyond their own trenches; in this way finding, although they succeeded in driving the assaulting party back, that they lost a great many and those of their bravest men, the rule laid down by Vauban, to withdraw timely and in good order from the point assailed, and, when the assailant has got well entangled in the abandoned trenches, fall upon him with vigor, in the state of disorganization in which he will naturally be found, was ordered to be rigidly followed out, which led to the most satisfactory results in checking these night attacks.

Finding on their arrival in front of Sebastopol that the Russian force was too strong to justify an ordinary open assault, the first idea of the Allied generals seems to have been, on breaking ground against the place, to bring a very heavy fire to bear upon its then weak defences, and, under the cover of its action, to attempt to carry the position by storm, and thus avoid engaging in regular siege operations, under the unfavorable circumstances of so near an approach to winter. But soon convinced, from the superiority of the Russian fire, that there was no alternative left but to go on with regular siege operations or to withdraw, the former course was decided upon, and the plan of attack first laid down was persevered in for four months under enormous difficulties, when it was changed and it was also decided to make approaches upon the celebrated Malakoff fort.

With the same view of abridging the siege by an open assault, the Allied generals opened a furious fire from all their batteries, now mounting 500 guns, on the 9th of April, and kept it up until the 14th, but though the Russian works were more or less injured, and their fire silenced to a considerable extent, it was not thought prudent, considering all the chances of success, to make an open assault then; and the time for doing so was put off, and the 28th of April designated for it, by which time the more advanced position gained by the trenches, and the injury done to the defences by the heavy fire both by day and night, it was expected would justify the attempt. The skill, however, shown by the Russians, in sheltering some of their guns to keep up a fire on the heads of the sap, and, in case of an open assault, to fire on the assaulting columns; and their perseverance in increasing their fire so soon as that of the Allies slackened, and also in repairing by night the damage done to their parapets, seemed to render the attempt at open assault as hazardous as ever; still, as the Allies saw it would be impracticable for them to find munitions to keep up indefinitely this kind of artillery duel, dispositions were actually made to carry out the plan previously proposed, and the assault was decided upon, to take place on the 28th or 29th of April. But receiving news just at this moment that large reinforcements were on their way, the Allied generals thought it more prudent to await the arrival of these troops than to enter upon what they had every reason to suppose would be a bloody struggle and might be a disastrous repulse.

This change of plan led to great relaxation in pushing forward the trenches, of which the Russians immediately took advantage to repair their damages and make additional defences. It was at this time also, that the French commenced to throw up in their rear the lines covering the harbor of Kamiesch, which would serve for an intrenched camp in case of any disaster, and enable them to reembark their army with comparative safety.

The Allied trenches were slowly pushed forward upon the points of attack into the month of June, when it was decided to make a general attack upon all the Russian works exterior to their main defences, as a preliminary step to making an assault upon these last. This decision was carried into effect on June 7th, and after a desperate struggle the Allies succeeded in carrying and holding these works. The French, who in this affair had to march over nearly 500 yards of ground more or less exposed to a front and flank fire, lost nearly 5,000 in killed, wounded, and missing, 207 of whom were officers.

Encouraged by this success and counting upon its demoralizing effects upon the Russians, the Allied generals determined to make a general assault upon the main defences and fixed upon the 18th June for that purpose. Fort Malakoff was the principal point to be gained, with the works upon its immediate left and right. The French, who had the centre and right of the attack, had about 400 yards of exposed ground to charge over; the English, who had the left, some 250 yards to reach their point. A furious fire was opened on the morning of June 17, from all the Allied batteries bearing upon the points to be assaulted, and kept up without intermission throughout the day, and preparations were made on the night of the 17th to launch the columns of attack early the next morning. From some of those small *contre-tems* by which all such affairs are liable to failure, one of the French columns was launched too soon and another did not come up in time. The result was, that from this want of concert, and the terrific fire of the defences, the French were repulsed on all points, with a loss of about 2,500 in killed, wounded, and missing, of whom 200 were officers. The English were equally unsuccessful on their point.

The Russians, who seemed fully prepared for the occasion, met the attack by their infantry mounting upon their own parapets to deliver their fire on the advancing columns. This contributed greatly to their losses, which were nearly 6,000 in killed and wounded, of whom 155 were officers, but only two of whom were killed. The killed, also, among their privates were some 500 men less than among the French, who lost 33 officers killed.

After this repulse the regular operations of the siege were resumed and perseveringly pushed forward under great difficulties and discouragements until the commencement of September. Literally stopped by the difficulties of the ground which was, at most of the points, solid rock, it seemed a useless sacrifice of life to attempt getting nearer to the points to be assailed with no other covers but such as could be formed of fragments of rock. The French at this time had worked their way to within 25 yards of the ditch of Fort Malakoff; upon their right to within 40 yards of the work known as the Little Redan, where they were on the bare rock; the English, in like condition, were stopped at 200 yards from the Great Redan; and on the side of the city, where the trenches were first opened, the French were from 50 to 70 yards from the nearest salients, and opening a way for themselves by mining.

Further delay appearing a useless sacrifice of life and time, the Allied generals decided to make the final general assault on Sept. 8. For several weeks the Russians had been subjected to an incessant fire from the Allied batteries, which now mounted 814 pieces in all, by which their loss was about 18,000 men in 20 days. From Sept. 5 to Sept. 8 alone, their losses were between 4,000 and 5,000 men. This terrific fire was kept up until noon, Sept. 8, when, by referring to their watches, which had been set for the occasion, the order was given, by the Allied general officers in command of the assaulting columns, to move forward upon the points to be assailed. The first rush carried all the columns into the works, but they were met with so murderous a fire from the Russians that they were soon driven out at every point, except at Fort Malakoff, which, after a terrific struggle, remained in the possession of the French and decided the fate of Sebastopol.

The total losses of the Allies in killed, wounded, and missing, were 10,054; those of the Russians nearly 12,000 in this one memorable assault on earthworks of a comparatively weak profile which, for many days previous to the assault, had been subjected to an incessant storm of projectiles from over 800 pieces of artillery.

The losses met with by the Allies in carrying the exterior defences, June 7th, their repulse in the assault on the main defences, June 18th, and the desperate and for a time doubtful encounter, Sept. 8th, show the bloody and hazardous character of open assaults upon intrenchments even when made under the most favorable circumstances; and they teach the lesson that nothing but imperative necessity will justify their being made when the object in view can be otherwise attained.

The resistance offered by the comparatively weak defences of Sebastopol, gave rise at the time to the expression of doubts by military men in Europe of the necessity of what are known as permanent works. A like question has been agitated among ourselves, growing out of the sieges of Yorktown, Vicksburg, and Fort Wagner. Nothing more pertinent perhaps can be said upon the subject than to quote the remarks of Marshal Niel, who conducted the final siege operations of the French. He says:

"Struck with the great length of the siege of Sebastopol, some foreign officers have called in question the necessity of masonry scarps for the defence of fortified places.

"Sebastopol, a vast intrenched camp covered by field works of strong profile, derived its chief means of resistance from a source which is only to be found in large naval arsenals, and in a large army having its communications with the interior of Russia unobstructed.

"If the main enclosure of this place had been provided with efficient scarp walls, if it had been necessary to breach these walls, and to penetrate into the place through the narrow defiles of these breaches, defended in rear by a numerous army, Sebastopol would have been under the circumstances impregnable.

"Let the siege works before Sebastopol, in effect, be compared with what usually takes place in an ordinary siege, and it will be seen that up to Sept. 8, 1855, the day of the final assault, the only siege works completed, and those after extraordinary exertions, were such as precede the crowning of the covered-way of a regularly organized permanent work. The most difficult and most murderous parts of the works of a regular siege had not yet been entered upon, and there was no need of doing so, as the ditches and parapets of Sebastopol, as the event proved, were not unassailable by an open assault. The difficulty was as much to conquer the Russian army in a defensive position which they had had a long time to strengthen, as in overcoming the obstacles presented in the fortifications. Our trenches having been pushed forward to within some 30 yards of the defences gave to us the choice of the moment for making the assault, when, having driven the enemy to his temporary shelters, by the heavy fire of our artillery, our columns were enabled to rush forward into the works before the enemy had time to make preparations to meet the assault; to have pushed our works further forward in such a case would have enabled the Russians to have seized the advantage of assaulting them.

"The absence of scarp walls, which would have secured the place from an escalade, exercised not less influence upon the defence, as it forced the besieged to maintain, always on duty, a large body of men in reserve, in the rear of their works, ready to repel an open assault to which they saw themselves constantly exposed from the moment the siege commenced.

"Finally, it is also to be observed that these troops held in reserve, and who were decimated day and night by our batteries, might, at any moment, have sallied out of the defences through wide openings instead of the narrow defiles through gateways and over draw-bridges, the usual outlets of permanent works; in this point of view they were a standing menace to the besiegers, who at any moment might have found their trenches assailed by the greater portion of the Russian army.

"Neither party, therefore, found themselves under the circumstances which ordinarily attend the siege of a permanent work which is secured from an open assault by scarp walls."

In executing this herculean task of eleven months of open trenches, driven through a rocky soil under the exposure to a formidable fire by which the labors of the night, carried on with great losses, were swept away during the day, the Allies executed nearly 50 miles of trenches, besides their batteries, and the lines thrown up as a circumvallation and those to cover their retreat in case of necessity. To execute these works the French alone consumed about 80,000 gabions, 60,000 fascines, and over a million of sand-bags.

The English, from the experience gathered in this siege, have proposed some modifications in the engineering practice of their schools. They propose no modification in the profiles of their approaches or parallels, in the construction of the parapets of which, in this siege, from a want of a sufficient supply of trench materials, they resorted to every expedient at hand, using powder barrels, casks, fragments of rock, etc., to shelter the men from view when gabions, sand-bags, etc., could not be obtained. They remark particularly on the necessity of having a good drainage for the trenches, since the men will frequently run the risk of exposure to the enemy's fire by walking along the reverse of a trench rather than wade through the mud and water of one badly drained.

They found that the ordinary distance of 18 to 20 feet between the axes of direct embrasures did not give sufficient room for handling conveniently guns of heavy calibre, and have settled upon 27 feet as a more suitable distance. In light soils they propose from 25 to 30 feet for the thickness of the parapets of batteries exposed to the full effect of the heaviest projectiles. In forming their embrasures they recommend a width of from 2 feet 6 inches, to 3 feet 3 inches, for guns varying from 32-pounders to the heaviest calibre. They give the preference to iron gabions for revetting the cheeks of embrasures near the mouth, and to gabions having 2 feet 6 inches diameter and a height of 3 feet 9 inches over those of the ordinary dimensions used for the same purpose.

In the construction of their powder magazines, they placed the floor, whenever practicable, 10 feet below the surface of the ground, giving it a ceiling of the heaviest scantling to be procured, over which was laid a layer either of sand-bags or large fascines, and a covering of earth over all so as to make the entire depth of cover at least 9 feet. This roofing rested on strong frames placed transversely, which were covered on the sides by thick boards, the dimensions in the clear within being 6 feet in width and 6 feet in height.

Shell rooms were provided where needed in the batteries, and look-outs arranged in some secure part to watch the ranges of the projectiles and their effects.

For the convenience of the service and the comfort of the troops, they recommend that the names of the batteries and different parts of the attack should be painted on boards and placed in conspicuous positions, with finger posts to point out the direction to be taken to reach any designated part; that in very hot weather awnings should be arranged to shelter the guards of the trenches; and a good supply of water be provided for the men in barrels or metal vessels sunk in the earth at secure points near at hand.

In their open assaults, both the French and English used, with great advantage, light scaling ladders to bridge the ditches of the points of attack. The French had theirs made for the occasion, and of sufficient length to give an over-lap of 5 feet to secure a safe support for each end. These, placed on a horizontal windlass, were readily run out by a few men across the ditches to rest securely on the opposite side, and being rapidly covered with boards, formed a bridge for the assaulting column. The English recommend, for this and the purposes of scaling, what is known in their service as the 12 feet joint scaling ladders, as the most convenient, with some additional 6 feet joint to be used in combination with the 12 feet joint when necessary.

SIEGE OF VICKSBURG.

The defensive line around Vicksburg was somewhat analogous to that inclosing Sebastopol, occupying an extent of between 7 and 8 miles, along the dividing ridge of several small streams, a part of which emptying into the Mississippi, north of the city, and a part south of it, drain a very singular network of narrow valleys and ravines into which the surrounding country is broken. This curious natural feature lent itself admirably to the purposes of a defensive position. Forming a continuation of the high ground or bluff along the Mississippi, upon which the city is built, the ridge runs back from the river at a point about a mile and a half north of the city, in an easterly direction, for about the same distance, and then bending south runs nearly parallel to the course of the river, and unites again with the bluffs about 3 miles below the city; thus, with the bluffs along the river, completely encircling the city with a natural defensive position commanding the approaches to it both by land and by water.

The natural advantages of the position had been well seized upon by the besieged, who had erected a continuous line, consisting of strong works, placed on the most commanding and salient points, connected by a line of entrenchments, to guard the land approaches; and batteries of heavy guns along the river bluffs to meet a naval attack.

Failing in a general open attack, which was made April 22, 1863, to carry this line, a siege was decided upon, and the place was regularly invested both on the land and river side, whilst a part of the army was thrown forward in observation, to prevent any attempt of a succoring force from throwing troops or supplies into it. The besiegers were provided with a suitable siege train, particularly in mortars, and regularly trained engineer troops. Trenches were opened against the defences, and the siege works prosecuted with vigor from the day after the failure of the open assault until July 4th, when the place capitulated.

No official details of professional interest have thus far been published of this siege, which has had such important results. The ground, although so favorable to a defensive position, presented many advantages, from its broken character, to the besieging force, in good positions for batteries, and in enabling them to open their first parallels at from 500 to 800 yards only from the defences. Approaches from these positions were run upon the most salient and commanding points, north and east of the place, until the besiegers had approached within a few feet of the ditches, and their sap rollers no longer afforded shelter to the trench. At this stage mining was resorted to on several points with successful results, and preparations were made to carry the place from the points gained by an open assault, when it capitulated.

Among other expedients, the besiegers, finding themselves much annoyed by the bursting of 6 and 12 pounder shells, which were rolled over the parapets into their trenches, and having no small mortars with which they could relieve themselves from this annoyance, resorted to the expedient of making wooden mortars to throw shells of the same calibres. These were made of gum logs well hooped with iron, and were found to answer their purposes very well, some of them being still serviceable after firing a hundred rounds.

SIEGE OF FORT WAGNER.*

The position of this work presented a combination of natural features unfavorable to regular approaches of a character so unusual as to make all the details of its siege, which fortunately have been given with great minuteness in the published official account, of marked professional interest.

Situated near the north end of Morris Island, a narrow strip of dry ground, formed of sand-hills nearly thirty feet in height at some points and at others so low as to be swept over by high tides, which lies between the entrance to Charleston harbor and a broad flat of soft marsh intersected by numerous creeks mostly navigable for boats, the only line of approach to the work was over this narrow strip, which at one point, where the sand-ridge is lowest, is only twenty-five yards wide.

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* Engineer and Artillery Operations against Charleston, by Major-General T. A. Gillmore, U. S. Volunteers. Published (by authority) by D. Van Nostrand, New York.

This line of approach was enfiladed by the main line of the work, a heavily armed bastioned front, and by the guns of Fort Sumter, and of a small work, Fort Gregg, both in the rear of it; and was swept in flank, on the marsh side, by the guns of Fort Johnson and several isolated batteries that had been thrown up for the purpose on James Island. The work thus presented on its assailable side a defensive line longer than the front of approach at most points; particularly in its immediate vicinity, where the strip available for the approaches was only about *twenty-five* yards wide. Whilst upon none of these works could any but a front fire be brought to bear from the line of approach, their fire could all be concentrated upon every point of it, to within a near approach to Fort Wagner; so that, in fact, after reaching within a certain distance of the defences, the besiegers, instead of being the enveloping, became the enveloped party, and for some time were brought to a stand-still, by the powerful fire concentrated upon them.

The main front of Fort Wagner is about 200 yards long and of a strong profile, having a wet ditch in which, by means of sluices, the tide could be let in and retained; both the scarp and counterscarp, at the most assailable points, were formidably fraised, and obstacles formed of planks with spikes were placed at the foot of the scarp. It had a heavy armament bearing on the line of approach, and the interior was provided with strong bomb-proofs to shelter a garrison of 1,500 men, formed of two thicknesses of heavy logs covered with some ten feet of sand. In addition to these defences, the ground immediately in advance of the ditch, and on the line of approach near to it, was rendered very unsafe by a large number of torpedoes buried in the sand, and so arranged that it was hardly practicable to pass between them without treading on some portion of the apparatus for exploding them.

Wishing to avoid the time that would be consumed in making regular approaches, it was decided to attempt to carry the work by open assault. Two open assaults were made; the first, July 11th, the day succeeding the capture of all the outer defences on the island, failed, the troops reaching the parapet, but being driven back by the heavy fire of the work. The second, July 18th, after establishing the first parallel and erecting several counter and mortar batteries against the defences, mounting in all forty-two pieces, from which a severe fire was kept up during the day until about twilight, when the columns of attack pushed forward, and, in the face of a formidable fire from all the defences, a portion of the troops made their way into the work, and held a part of it for about three hours, when they were forced to retire. Thus adding another example to the uncertainties of open assaults, even under very favorable circumstances; for, in this instance also, the fire of the work bearing upon the line of approach had been completely silenced, and the garrison driven into their bomb-proofs before the assailing force moved forward.

The first parallel,* which was only about 200 yards in length, was opened at 1,360 yards from Fort Wagner, after the last assault, and was strengthened by a defensive line with inclined palisading run across a narrow part of the island, about 200 yards in advance of the parallel. The 2d parallel, about 300 yards in length, was opened July 23d, at 870 yards from the fort, upon a part of the island where a firm footing of sand stretches across it. This was converted into a strong defensive line against sorties, by an inclined palisading, a strong wire entanglement connected with the palisading and an abattis, and was armed with several guns. The 3d parallel, about 100 yards in length, was opened Aug. 9th, at 540 yards from the fort. To cover it from sorties on its flanks and front, a large portion of it was formed into a keep, the front of which was covered by an abattis and the gorge inclosed by a strong palisading.

Up to the time of constructing the 3d parallel the trenches were pushed forward by the flying sap, the men being led into position in the usual manner, and when placed each one covering himself as rapidly as possible by digging a hole for shelter. From this point forward the fire of the work was so severe that the full sap had to be used. It was found necessary to abandon the ordinary way of conducting this sap, and the following method was adopted: Covered at the head of the sap by an ordinary sap roller, which was pushed forward only a few inches at a time, the trench was excavated to a depth of only two feet without leaving any berm, and the earth thrown forward to the exposed end of the sap roller, so as to close up the gap between it and the parapet and thus give the leading sapper cover. This, though a much slower method than the usual one, was found to work well.

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* See Report of Major T. B. Brooks, A. D. C., (Assistant Engineer) on Engineering Operations.

The 4th parallel, about 170 yards long, was opened Aug. 21st at 350 yards from the fort; and finally, Aug. 26, a 5th parallel, about 100 yards long, at 243 yards from it, on a ridge from which the sharp-shooters of the besieged had been dislodged from their rifle-pits by a bayonet charge. The sap, from the moment of starting from the 3d parallel up to this position, was frequently stopped by the fire of the defences; yet in the face of this nearly half the line of trenches, from the 3d parallel to the crowning of the glacis around the ditch of the fort, which was done on the night of September 6, was executed at night by the flying sap in the usual way. This, however, was the most difficult period of the siege, particularly about the time of constructing the 5th parallel, when it was found impossible to advance further under the concentrated and severe fire of both artillery and musketry, until this fire could be brought under. Extraordinary measures were used for this purpose, the lighter mortars being moved forward into the parallels nearest the work, and a fire opened from them and from the batteries in the rear, aided by the fire of part of the fleet. This severe bombardment, which lasted for forty-two hours, was directed by night by the aid of several strong calcium lights, which, whilst they showed the defences, left the position of the besiegers in obscurity. The fire of the works was reduced to almost complete silence, and the sappers were enabled to push forward their trenches, with great facility and very trifling exposure, to their final position, when on the same night the work was abandoned.

Unlike sieges generally, where the besiegers are the enveloping party, and have a choice of positions both for their parallels and batteries, the circumstances in this case were reversed. Positions had to be taken for the parallels where the extent of the line seemed most favorable, and these from the 2d parallel had to be strongly secured both in front and on the flanks by palisades, abattis, &c., against sorties. The fire of the batteries, from their position in rear of the parallels and approaches, caused not only annoyance but loss, from the accidents of the premature explosion of shells and like causes. It is in these points of view that this siege, which besides offers many novel professional details, merits a careful study.

In the construction of the batteries there were several features of marked interest.* For the purpose of obtaining higher elevations and longer ranges for random firing than can be had with the usual siege carriages, rough and strong carriages were improvised for the occasion,—the wheels resting upon two side rails raised several feet above the platform on which the trail rested, like a similar device at Sebastopol, which enabled the gun to be fired under very great angles.

In constructing the foundations and epaulments for an 8-inch Parrott gun, named by the soldiers the "Swamp Angel," which occupied a position in a soft marsh, a difficult problem was happily solved in a very ingenious manner. Having by direct experiment ascertained the resistance offered by the soil on the superficial unit, the general bed of the structure was prepared by first laying and trampling down a thick stratum of the long grass cut in the marsh, over which two thicknesses of heavy tarpaulins were spread to receive a grillage formed of two thicknesses of heavy pine logs well bolted together; the interstices between the logs being filled with sand and the sand bags that had been too much injured for other purposes. To counteract any tendency to the unequal upheaving of the soil around the grillage when loaded with the epaulment, bags of sand were laid over the surface exterior to and joining the grillage.

In laying the grillage, a rectangular opening was left of sufficient dimensions to receive the platform of the gun. The soft mud within and below this open area was inclosed by sheeting piles, which were forced down by pressure to the firm soil, some 15 feet below, into which they were driven by heavy wooden mauls. Over this inclosed area, a bed of grass, well trampled down and then covered by two thicknesses of tarpaulins, was laid, upon which a layer of sand 15 inches in depth was spread and well rammed. Upon this bed a platform, consisting of three thicknesses of three-inch yellow pine plank was laid, the two lower crossing each other diagonally and resting on the bed of sand, and on a strip of scantling spiked to the sheeting at the same level as the top surface of the sand; the top course of plank rested on the heads of the sheeting piles and on the two lower thicknesses, the joints being parallel to the axis of the gun. By this combination a firm bed was sought to be secured to receive the platform and carriage of the gun, which would be independent of any settling in the general bed upon which rested the parapet and epaulments of the battery, constructed of bags of sand.

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* See Reports of Colonel Serrell, Commanding Regiment N. Y. Volunteer Engineers, and of Lieut. Michie, U. S. Corps of Engineers, on the Engineer Operations.

From the nature of the soil, a fine quartz sand, which when dry runs through the web of ordinary gabions and hurdle work, sand bags were found to be the best material for the revetments of batteries. When any part of the revetment was damaged it was usually repaired by a sod facing. A coating of an inch or two of the soft marsh mud placed over the slopes of the parapets and bomb proofs of the batteries was also found very serviceable in securing the men from much of the annoyance of the drifting sand in windy weather.

Among other novel expedients for securing the flanks of their parallels from sorties, a battery for two field howitzers, termed the surf battery, was built upon crib-work run out into the low water-line of the beach, on the harbor side, from the extremity of the 2d parallel. The parapet of this battery was constructed by bags of sand. The battery was connected with the trenches by a defensive barricade, formed of bags of sand laid on a platform built on crib-work, and formed the communication between the battery and trenches as well as a parapet for musketry and for a Requa battery.

To avoid attracting the fire of the besieged, the logs of the crib-work were mostly lashed together with rope and the whole anchored by short piles worked by hand about three or four feet into the quicksand.

Under circumstances very favorable to an active defence the besieged refrained from resorting to sorties, confining themselves to the effect produced by the fire of the work and from sharpshooters thrown in advance of it, and covered by rifle-pits, who kept up an annoying and destructive fire on the besiegers until dislodged by a bayonet charge. In fact, by covering the ground immediately in front of the work with torpedoes, the besieged deprived themselves to a great extent of the means of an active defence; as many of their men captured in the bayonet charge had no means of retreat but the dangerous one through this mesh-work of torpedoes.

This siege has confirmed the great vulnerability of masonry when exposed to the projectiles of heavy rifled guns within their effective ranges, and the slowness with which earthen parapets are destroyed by the same means, particularly, as was the case at Fort Wagner, when formed of sand. Whilst Fort Sumter, at a distance of over 4,000 yards, was silenced, and its mask walls destroyed by the heavy Parrott rifled guns, the sand parapet of Fort Wagner and the cover of its bomb-proofs were but comparatively slightly damaged; many of the projectiles, from their form, being deflected in striking the gentle slope which the sand had assumed from the effects of the fire, and most of the sand which was thrown up by the explosion of shells lodged in the parapet having fallen back into the crater of the explosion.

The uses made of the calcium light, and of the Requa battery, are novel applications of these means to siege purposes, and, having been found so serviceable in this instance, will, in all likelihood, form a part hereafter of siege apparatus.

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